CONFEDERATION PARK (HAMILTON)

MICROBIOLOGICAL SURVEY

1979

Ministry
of the
Environment
Ontario

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MICROBIOLOGICAL SURVEY

1979

Technical Support Section

West Central Region

Ontario Ministry of the Environment

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Preface

This report was completed at the request of the Hamilton City Council for an investigation into the causes of high bacterial populations in Lake Ontario, offshore of Confederation Park. Data were collected by the Ontario Ministry of the Environment, the Canada Centre for Inland Waters and the Hamilton-Wentworth Regional Health Unit.

While representatives of the above two outside organizations have reviewed this document, the conclusions reached do not necessarily reflect their opinions.

Acknowledgments

The authors H. D. Craig and Dr. S. S. Rao would like to express their appreciation to Dr. A. Qureshi and S. Janhurst (MOE, Microbiology Labs) for their help and suggestions in survey design and analyses. Staff of the Hamilton-Wentworth Regional Health Unit provided data from their surveys, without which, this study could not have been possible.

A. Thachuk, T. Waram and M. Thompson carried out the field sampling in an efficient and professional manner.

The manuscript was reviewed by Mr. S. Irwin, Dr. A. Qureshi and Ms S. Janhurst. Their comments and suggestions were very helpful in the final write up.

EXECUTIVE SUMMARY

This study was carried out as a result of a request by Hamilton City Council to determine the extent and causes of bacterial pollution along the Confederation Park shoreline in Lake Ontario. The survey method was designed to determine inputs to nearshore Lake Ontario in the study area and then determine fluctuations in nearshore bacterial populations in order to relate these factors.

The problem of elevated bacterial counts in the nearshore of Lake Ontario in the vicinity of Confederation Park appears to be a direct result of stormwater runoff in most cases. The problem of high bacterial counts in Smith's Creek appears to affect Lake Ontario only locally around the discharge point. Bacterial populations in nearshore Lake Ontario following a major runoff event are elevated, but decrease rapidly by an order of magnitude in the next 24 to 48 hours.

CONFEDERATION PARK BACTERIOLOGICAL SURVEY

1. INTRODUCTION

1.1 Background

The nearshore waters of Lake Ontario at Confederation Park at Hamilton occasionally show elevated levels of total coliform and fecal coliform bacteria which are above the Ministry of the Environment and Ministry of Health Guidelines for body contact recreation, resulting in posting of the beach as unsuitable for body contact recreation by the Hamilton-Wentworth Regional Health Unit. The contamination is transitory and not clearly related to a specific source. During 1978 the beach at Confederation Park was posted once for a three day period, August 27th to 30th.

In the fall of 1978, Hamilton City Council requested that the MOE carry out a study "To Review the Extent of Pollution in Lake Ontario along Confederation Park and Determine the source of such Pollution". As a result of this request, a series of meetings were initiated between concerned parties (including MOE regional staff, MOE laboratory services branch staff, Regional Municipality of Hamilton-Wentworth Engineering Committee, Hamilton Pollution Control Sub-Committee, the Regional Health Unit and the Hamilton Region Conservation Authority) in order to discuss the proposed project. A survey plan was arrived at and is described below.

1.2 Survey Method

The MOE survey consisted of two main parts, the first of which was the identification and sampling of various inputs to the lake, while the second part was concerned with determining the fluctuations in bacterial populations in near shore Lake Ontario following rainfall events. Water quality samples were collected during the morning at the stations shown in Figure 1.1. These were then transported to the MOE Toronto Laboratories as soon as possible.

The Hamilton-Wentworth Regional Health Unit monitored bacterial water quality on a routine basis daily from Monday to Saturday throughout the summer. These data were made available to the MOE and integrated with the results of our study. The Canada Centre for Inland Water (CCIW, Environment Canada) conducted a study under Dr. S. Rao on the bacterial quality of the plume from Hamilton Harbour. These data are included in this report.

1.3 General Significance of Bacterial Parameters

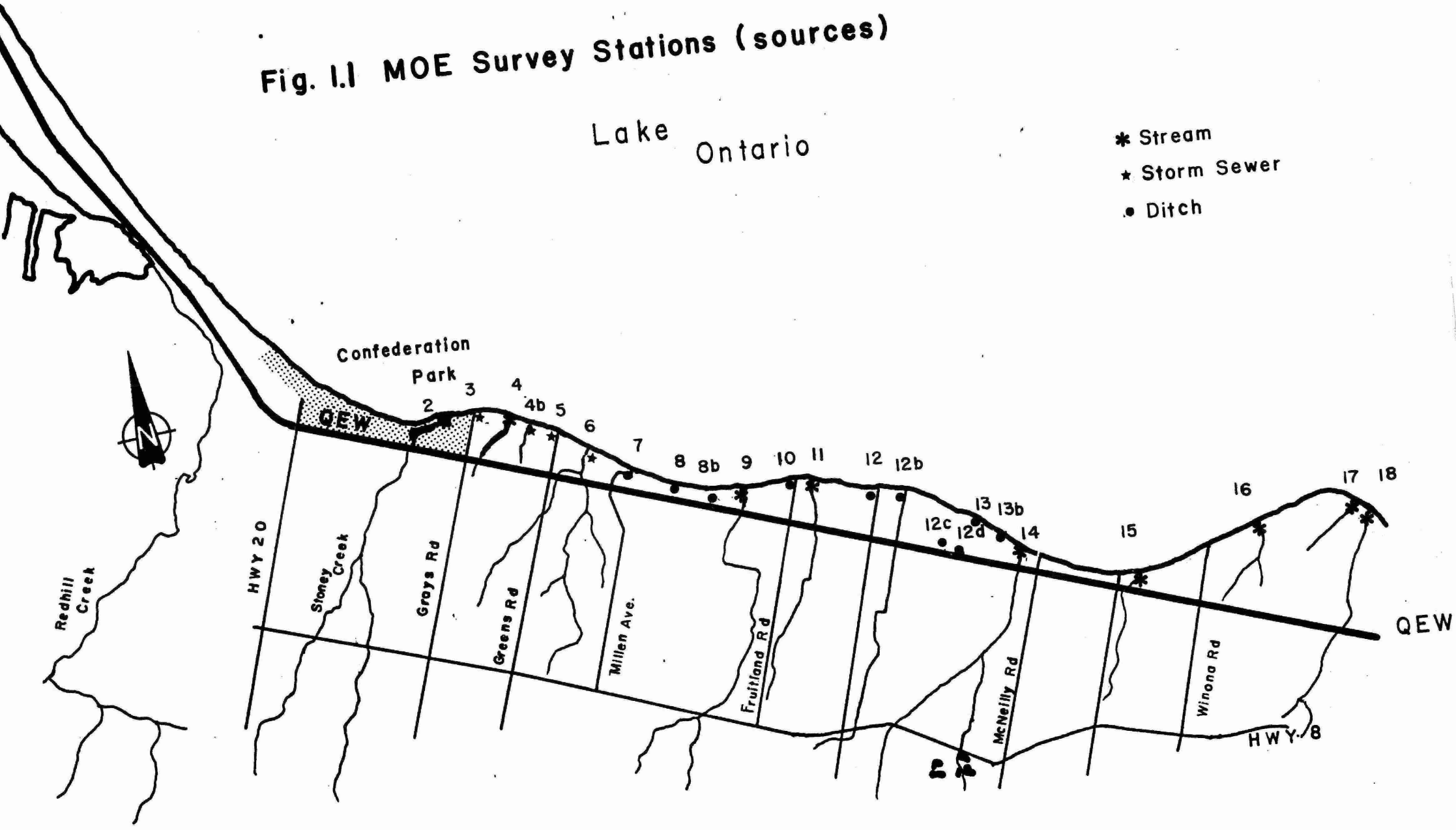
1.3.1 Fecal Coliforms (FC)

The fecal coliform group is associated with human and warm blooded animal fecal material. This test is useful as an indicator of relatively recent fecal pollution inputs, however, it is by no means completely selective for Escherichia coli, the coliform most directly related to fecal pollution. For body contact recreation the MOE has established an objective of 100/ 100 mL for fecal coliforms (MOE, 1978). As the detection of specific pathogens in water is often too expensive or time consuming, the presence of fecal coliforms is used as an indicator that such pathogens may be present.

1.3.2 Fecal Streptococci (FS)

This group of bacteria is used as indicators of fecal contamination from warm blooded animals including humans. It can best be used in conjunction with the FC parameter to indicate the nature of the potential fecal source. If the ratio of the geometric mean densities of FC to FS at pollution sources or outfalls exceeds 4.0 then the source is likely to be

Fig. I.I MOE Survey Stations (sources)



human in origin. A ratio of 0.7 or less indicates a non-human source. Ratios between these values are difficult to interpret and may be mixtures. Numerous environmental factors may influence the densities of FC and FS and thus care must be used in interpretation of the above ratio. The ratio is considered valid only when the FC density approaches or exceeds 100/100 mL (MOE, 1978).

I.3.3 Pseudomonas aeruginosa (PsA)

P. aeruginosa probably does not occur in waters unaffected by human activity and domestic animals (Hoadley, 1967). Isolates of P. aeruginosa are found in human feces and their presence in water is generally a direct result of recent fecal waste input from a nearby source. Their presence and frequent isolation indicates a potential health hazard. The organism is an opportunistic pathogen and has been identified as the causitive agent of a number of infections that may be transmitted through a contaminated water body to a susceptible host. Of chief concern to bathers is the association between P. aeruginosa and the disease known as otitis externia or swimmer's ear (MOE, 1978).

PsA populations in excess of 100/100 mL may occur in water recently contaminated by sewage. Populations of 10 to 100/mL are observed in streams immediately below sewage outfalls (Hoadley, 1967). Although some sterile waters support growth of P. aeruginosa in the laboratory, populations of P. aeruginosa are rapidly reduced in natural surface waters, being diminished ordinarily by over 90% in three hours. P. aeruginosa appears to be a sensitive indicator of the contamination of surface water by sewage, and municipal and barnyard runoff (Hoadley, 1967).

I.3 Aerobic Heterotrophic Bacteria (HB)

The HB count is designed to enumerate as large a number as possible of those bacteria that require some carbon for their growth. The concentration of Heterotrophic bacteria in water is affected by levels of

organic nutrients present. Densities of Aerobic Heterotrophic bacteria in lakes of high trophic status are greater than AHB levels in oligotrophic lakes (Rao & Jurkovic, 1977). Large numbers of heterotrophs in water indicate increased productivity and deterioration of water quality.

1.3.6 Candida albicans (CA)

C. albicans is a pathogenic yeast having an intestinal habit in humans, some animals and birds. As it is not normally associated with non-polluted waters, its presence may indicate fecal contamination. It is responsible for a number of superficial (oral, vaginal and cutaneous) infections in humans. C. albicans also occurs as a normal component of the body flora. It appears that it behaves as a pathogen only in hosts whose resistance has been altered by some predisposing factor (Sherry et al, 1979).

1.4 Previous Studies

1.4.1 Hamilton-Wentworth Regional Health Unit Monitoring (1978)

The Hamilton-Wentworth Regional Health Unit has collected bacterial data from the Confederation Park area for several years. The data from 1978 show a pattern of rapidly varying population densities. That is, for a period of time, most of the values will be acceptable (based on MOE guidelines for body contact recreation), then, for some undefined reason, populations will increase across the local lake front. These levels then usually drop rapidly to the normal background levels. These elevated levels may, in some instances, persist for several days. A detailed evaluation of 1979 survey results is contained in Section 2.1.

1.4.2 CCIW Bathing Beach Study

A study published by the Canada Centre for Inland Waters in Burlington "Occurence and Significance of Candida albicans in Lake Ontario Bathing Beaches" by Sherry et al (1979) described bacterial studies completed on specific days during summer 1977 on Hamilton Beach, adjacent to the Burlington Canal and Confederation Park. The results showed for both

areas of interest, maximum populations (F C and F S) usually occur in a narrow band adjacent to shore (1 meter) and that highest mean numbers for all populations occurred in July and August. In their conclusions they state:

> "Maximum numbers of all microbial parameters were observed in July and August in association with peak bather loads at these beaches. When microbial population levels were adequate, a decreasing distribution pattern from the shoreline to the offshore waters was observed. In only one instance does our data suggest that a beach has been subjected to fecal contamination (St. Catharines). Storm water runoff seems to be the most possible source of the contamination in most other cases (Hamilton), although the possiblity that the bathers themselves may contribute to the pollution levels of a beach must be considered".

1.4.3 CCIW Study (Hamilton Harbour Plume)

During 1977 and 1978, an extensive bacterial sampling program was undertaken by the Microbiology Laboratories of the Canada Centre for Inland Waters under the direction of Dr. S. Rao. Some of the results of this program are shown in Appendix 1. These figures clearly define the extent of the plume from Hamilton Harbour in Lake Ontario. In most cases, the plume is localized; in any case, under all conditions studied, the plume tends toward the east, away from the Confederation Park area.

Water from Hamilton Harbour, being warmer than that in Lake Ontario, will tend to float on the surface of the lake water. In the plume, the highest bacterial populations were measured in the surface samples, however, averaging all the samples from the various depths still produced the same basic patterns.

2.0 SURVEY RESULTS & DISCUSSION

2.1 Hamilton-Wentworth Regional Health Unit Data (1979)

As previously stated, the Hamilton-Wentworth Regional Health Unit (HWRHU) carried out their routine sampling from Monday through Saturday on a weekly basis throughout the summer at the stations shown in Figure 2.1. The data for summer 1979 are shown in Appendix 2.

Figure 2.1 Hamilton Wentworth Regional Health Unit Stations

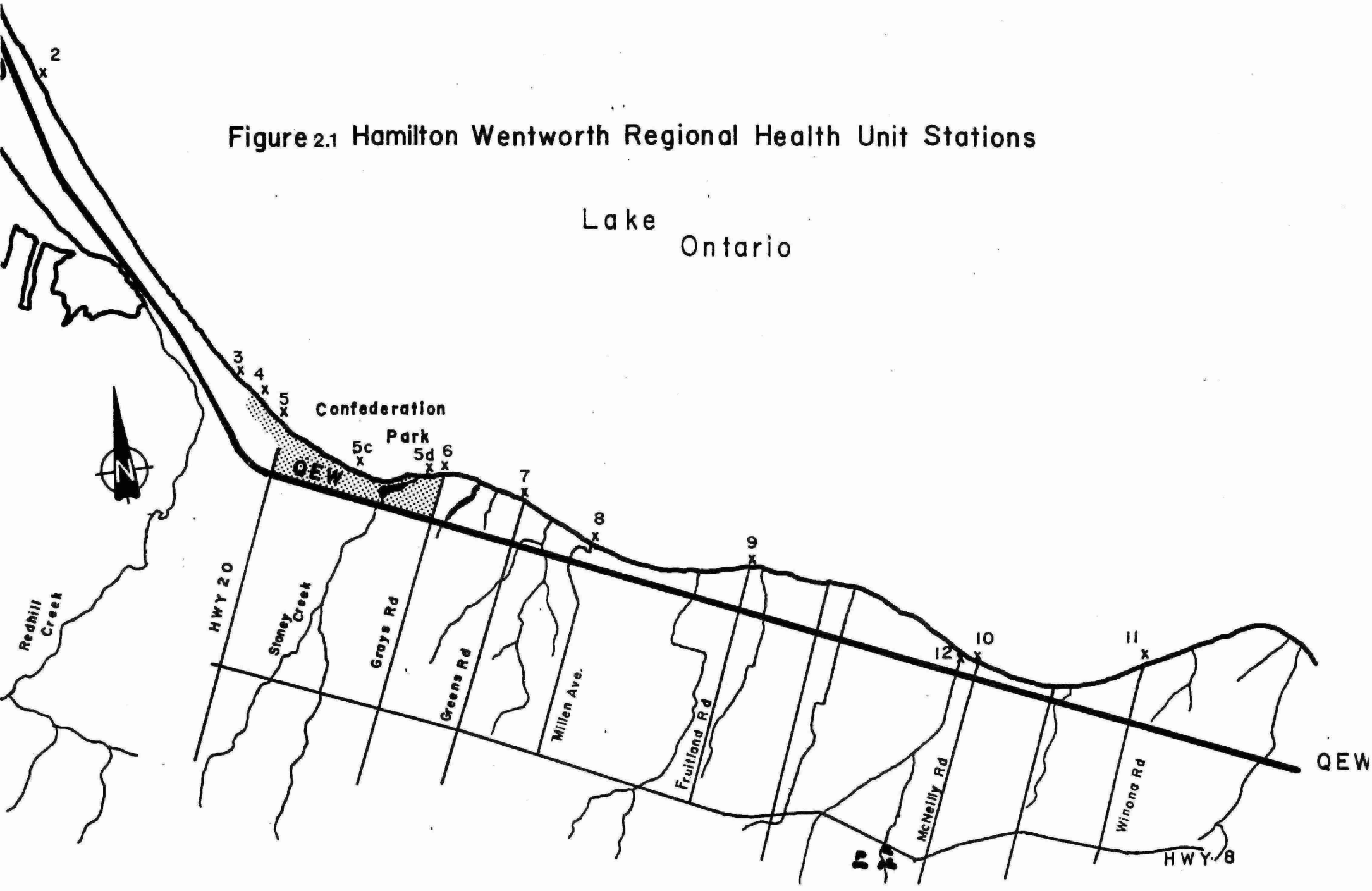


Figure 2.2 Variation in Fecal Coliform Population, Max. Daily Air Temp., Precipitation vs Time.

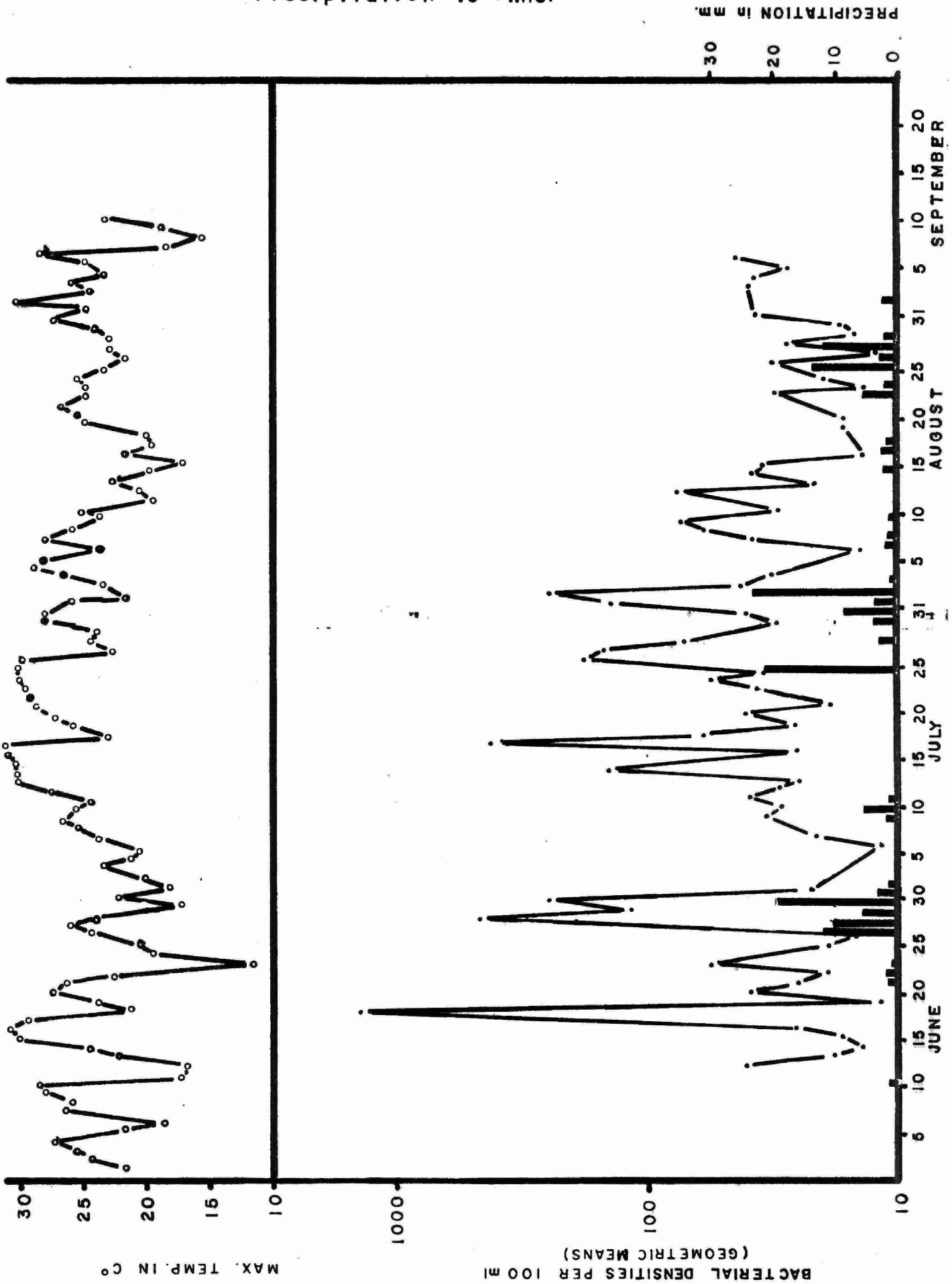
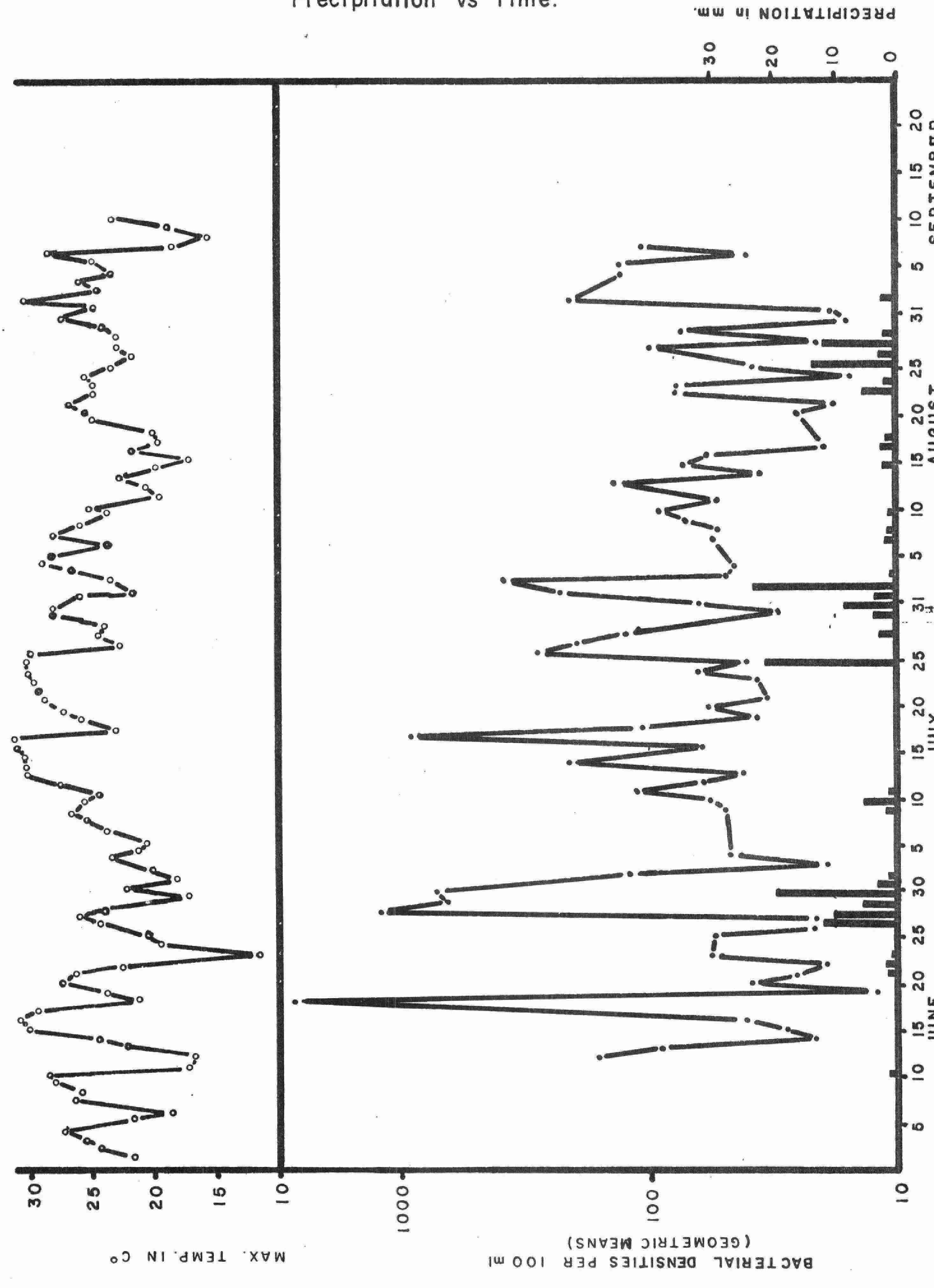


Figure 2.3 Variation in Fecal Strep. Population, Max. Daily Air Temp., Precipitation vs Time.



Fecal coliform and fecal streptocci data are summarized in Figures 2.2 and 2.3 respectively. These figures show the variation in the geometric means of the daily population of all the Lake Ontario nearshore stations over time, and compares them to (a) precipitation (Bar graph on bottom axis) and (b) maximum air temperature. These graphs suggest a relationship between the high bacterial counts (FC>100/100 mL, TC>500/100 mL) observed on June 29, 30; July 26 and August 1 and preceeding rainfall. High bacterial counts (FC>100/100 mL, TC>500/100 mL) observed on June 18, July 14 and 17 are not related to precipitation but may be related to elevated temperature. These elevated air temperatures would result in a greatly increased user load at the beach.

A more detailed examination of the data, station by station, is shown in Appendix 2 and helps to further substantiate the above observations.

In Appendix 2, values exceeding the MOE guidelines for body contact recreation are highlighted for ease in reading.

Weather factors that may have affected these parameters are also shown at the bottom of the table. Complete Meterological Summaries are provided in Appendix 3. These data show the following general features:

1. The general effects of the unnamed watercourse flowing past the E. D. Smith plant to Lake Ontario (referred to in this report as Smith's Creek) on the local Lake Ontario shoreline. This is shown by the high bacterial counts (TC>1000/100 mL) found at McNeilly and Winona Roads (Hamilton-Wentworth Regional Health Unit stations 10 and 11, respectively) on numerous occasions. This level of contamination was observed on June 12, 13, 16, 20, 21, 23, 25, 26; July 11, 16, 18, 19, 24, 25, 28; August 3, 13, and 29. It should be noted that on these days the contamination is local and does not appear to extend beyond the waterfront at the adjacent roads (H.W.R.H.U. staions 9 and 11). The source of bacteria to this creek is predominently the E. D. Smith factory at Highway #8 and will be discussed in more detail in the report under the MOE survey results.

2. The effects of Stoney Creek were observed in the Confederation Park area as high bacterial counts (TC >1000/100 mL, F.C. >100/100 mL) on July 12, August 8, 9 10, 15 and 23. The source of contamination to Stoney Creek is the urban storm water runoff. It is well known that bacterial populations in urban runoff approach the level of dilute sewage. (Dutka and Rybakowski, 1978).

3. The effects of major rainfall events were clearly shown in the data from June 28, 29, 30; July 12, 26, 27; and August 1 and 2. On each of these days the occurence of large bacterial populations (TC 1000/100 mL, FC >100/100 ml) was preceeded by precipitation events, causing substantial urban and/or rural runoff and associated contamination. It is important to note that this is a region-wide feature, extending from the Burlington Canal to Winona Road.

4. The high bacterial counts (TC > 1000/100 mL, FC > 100/100 mL) observed on June 18, July 14 and 17, have no obvious causes and are not related to urban runoff. As a certain set of conditions may cause transport along the lakeshore from a given source, wind data were examined for the given days as shown below.

Date	Wind Speed Km/hr	Direction
June 17	19.2	SSW
June 18	15.5	E
July 13	9.0	NE
July 14	9.2	SSW
July 16	9.9	WNW
July 17	14.6	swirling but max. velocity from NE

As can be seen, wind direction on these days with high bacterial counts, and those days immediately preceeding them show no similarity and are indeed highly divergent. Such conditions can be expected to set up different degrees of longshore drift and dispersion. In light of this it does not seem reasonable to attribute these events to transport from a specific source.

It is interesting to note that on the above days, air temperatures were extremely high. In fact, without exception each of these high readings was preceeded by the three highest temperature days of that month (please refer to meteorological data in Appendix III).

Date	Max. Temp. (^{o}C)	Mean Temp. (^{o}C)
June 15	30.0	23.4
June 16	30.9	24.2
June 17	29.2	22.0
July 12	30.1	24.2
July 13	30.1	30.9
July 14	30.1	25.5
July 15	31.0	25.1
July 16	31.0	24.3
July 17	23.0	19.9

All of these values are far above the monthly mean air temperature (June = 17.5 ^{o}C, July = 20.8 ^{o}C). During August, 1979, these extended hot periods did not occur, in fact, the mean monthly temperature was 1^{o}C below normal for that month. These data raise some interesting questions. During these prolonged hot periods, usage of the beach area will be at a maximum. In these cases it is not possible to rule out the effects of the bathing population on bacterial water quality. Previous studies have demonstrated a possible relationship between bather load and elevated microbial populations (Foster et al, 1971).

2.2 MOE Survey Results

2.2.1 General

Phase I of the MOE Field Study consisted of the collection of bacterial samples from the numerous inputs to Lake Ontario (Figure 1.1). An examination of flows indicates the only major inputs to Lake Ontario are; Stoney Creek (station 2), the large storm sewer east of Grays Road (station 6), Smith's Creek (station 14), and the unnamed stream at station 15. The remainder of the stations consist of intermittent streams, ditches

and small storm sewers. The results can be divided into wet and dry weather runs (Table 2.1). These data show that bacterial counts during or immediately after periods of precipitation are consistently higher than those from dry weather periods. Also during periods of storm runoff, flows will be much greater, as will total loadings to Lake Ontario. During sampling under wet weather conditions it is unlikely that samples were collected during peak bacterial populations in the streams. Studies have shown that monitoring of the "initial flush" alone is not important in bacteriological studies, and peak microbial populations can occur at any time during runoff events (Qureshi, 1978). In general, the inputs show higher bacterial populations due to runoff episodes.

2.2.2 Smith's Creek

The bacterial counts on samples from the mouth of Smith's Creek are normally high, but do display some fluctuations. The main source of the contamination to the creek is the E. D. Smith plant at Highway #8 which discharges a lagoon containing waste from fruit processing operations and some sanitary hook-ups in the plant. The organic loadings (BOD, etc.) from the discharge will vary, as the production of the plant is cyclical, corresponding to peak periods of fruit production on the surrounding farmlands. While the effluent is presently being chlorinated the effectiveness of this will vary inversely with the amount of organic matter in the waste stream. This shows up in the samples from their outfall as the numbers of fecal coliform vary from 4 up to 16,000/100 mL. The chlorination appears to be effective in the short term, but increased populations are seen in Smith's Creek below Highway #8, possibly indicating in-stream regrowth of bacteria. The samples from Smiths Creek show large fluctuations in quality, but in general bacterial quality in the entire system is very poor.

2.2.3 Lake Ontario

Phase 2 of the MOE study was directed at trying to determine the bacterial populations in Lake Ontario, adjacent to the shoreline. In order to do this, five transects were constructed perpendicular to the shoreline

TABLE 2.1 Bacterial Populations in Watercourses draining to Lake Ontario in the Study Area

Station #[1]	Fecal Coliform per 100 mL		Fecal Streptococci per 100 mL		Heterotrophic Bacteria per 1 mL		Pseudomonas aeruginosa per 100 mL		Candida albicans per litre	
	Dry[2]	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
2	85	132	78	272	325,000	840,000	3	17	2	7
4	13	14	26	108	116,000	264,000	3	4	0[3]	7
6	397	2,470	289	4,860	630,000	1,640,000			4[3]	20
7	27	159	240	1,660	178,000	316,000	6	11	2	3
8	103	1,000	159	2,310	352,000	1,230,000	7	98	2	6
9	54	843	271	2,810	115,000	938,000	3	36	2	6
11	116	1,240[3]	756	8,600[3]	112,000	2,150,000[3]	3	340[3]		
12b	486	423	828	2,250	1,040,000	1,400,000	4	8	2	7
12d	162	600	448	1,750	195,000	1,100,000	4	7	2	7
14	2,125	1,240	5,043	12,060	1,450,000	2,130,000	4	8	2	14
15	78	184	63	1,363	540,000	920,000	4	28	2	6
17	4	45	85	460	111,000	35,600	3	17		
18	60	238	155	2,060	62,000	480,000	5	8	0[3]	6
All stations										
	90	330	240	1,670	257,000	723,000	4	18	2	7

1 only those stations with observable flows were sampled
2 Dry : stream sampled following period of no precipitation
Wet : stream sampled immediately following or during precipitation events
3 only one sample

Note: all values expressed as geometric means of samples

as shown in Figure 2.4. Samples were collected daily at 1, 10 and 20 meters from shore, for a three-day study period. These transects were sampled both during dry weather and wet weather following runoff events.

Figures 2.5a, 2.5b and 2.6 show the geometric mean of the observed bacterial population density for all of the transects. Figure 2.5a shows that in the majority of cases the maximum population of fecal coliform is seen in the near shore zone (ie 1-10 meters). Following a precipitation event, the populations of fecal coliforms are higher in a wide zone (1-20 meters) for the first 2 days. On the third day following the precipitation event, the near shore zone still shows high density (10 to 100 per 100 mL) but the offshore zone (10 to 20 meters) has fallen to approximately 2/100 mL. The same observation can be made from Figure 2.5(b) which shows fecal streptococci densities. In figure 2.6, the Heterotroph population densities per mL show very similar levels over the 3 days of dry weather. For the samples following the precipitation events, day 1 shows elevated levels (compared to the dry samples), while day 2 and day 3 levels subsequently decrease until by day 3 the 10 and 20 meter samples have decreased by approximately an order of magnitude from the day 1 value.

It is significant to note the difficulties in this type of event sampling. The ideal sequence would have been to have a heavy rainstorm (approximately 10 mm of precipitation) followed by 3 days of calm, dry weather. Samples on the transect would then have represented the effect of the sudden input due to runoff followed by a period of recovery. Two separate series of wet samples were carried out on July 31 to August 2 and August 23 to August 25. The July 31 series was not ideal with an initial rainfall of 8 mm in the afternoon, follwed by a slight rainfall 3.0 mm on August 1 (day 2). This was then followed by an intense rainfall of 23.2 mm in the morning of August 2 (day 3). The Hamilton-Wentworth Regional Health Unit data for this time period (Appendix 3) show elevated levels on July 31 (3 stations having FC > 100/100 ml), more extensive contamination on August 1 (7 stations FC > 100/100 ml) and widespread effects on August 2 (12 stations FC >100/100 ml) due to the sudden intense rainfall that morning. It should be noted that on August 2, only the 1 meter stations were sampled due to adverse wave conditions. This continuing rainfall and resultant runoff, greatly complicated the interpretation of data for this run.

Figure 2.4 MOE Transect Locations

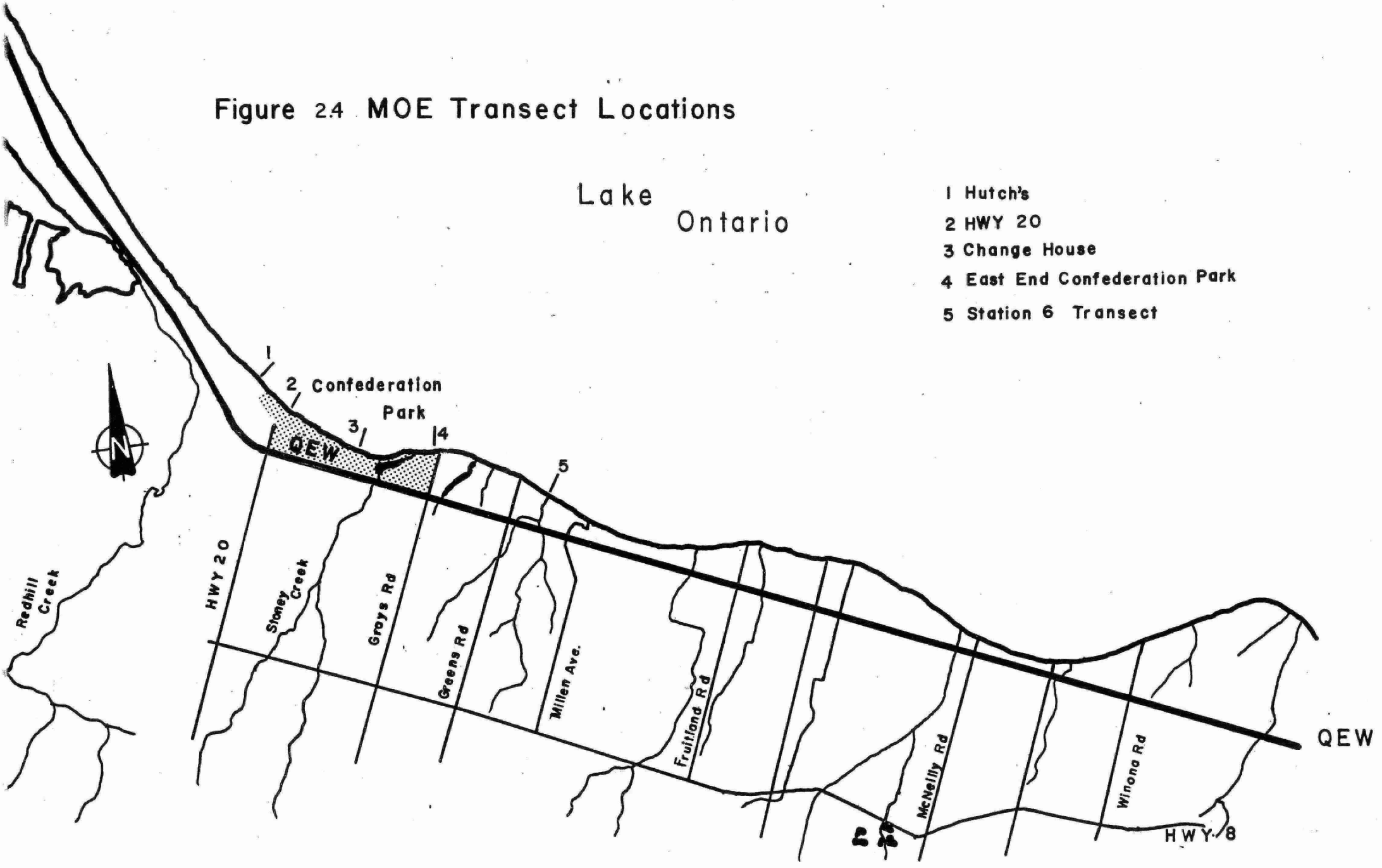


Figure 2.5

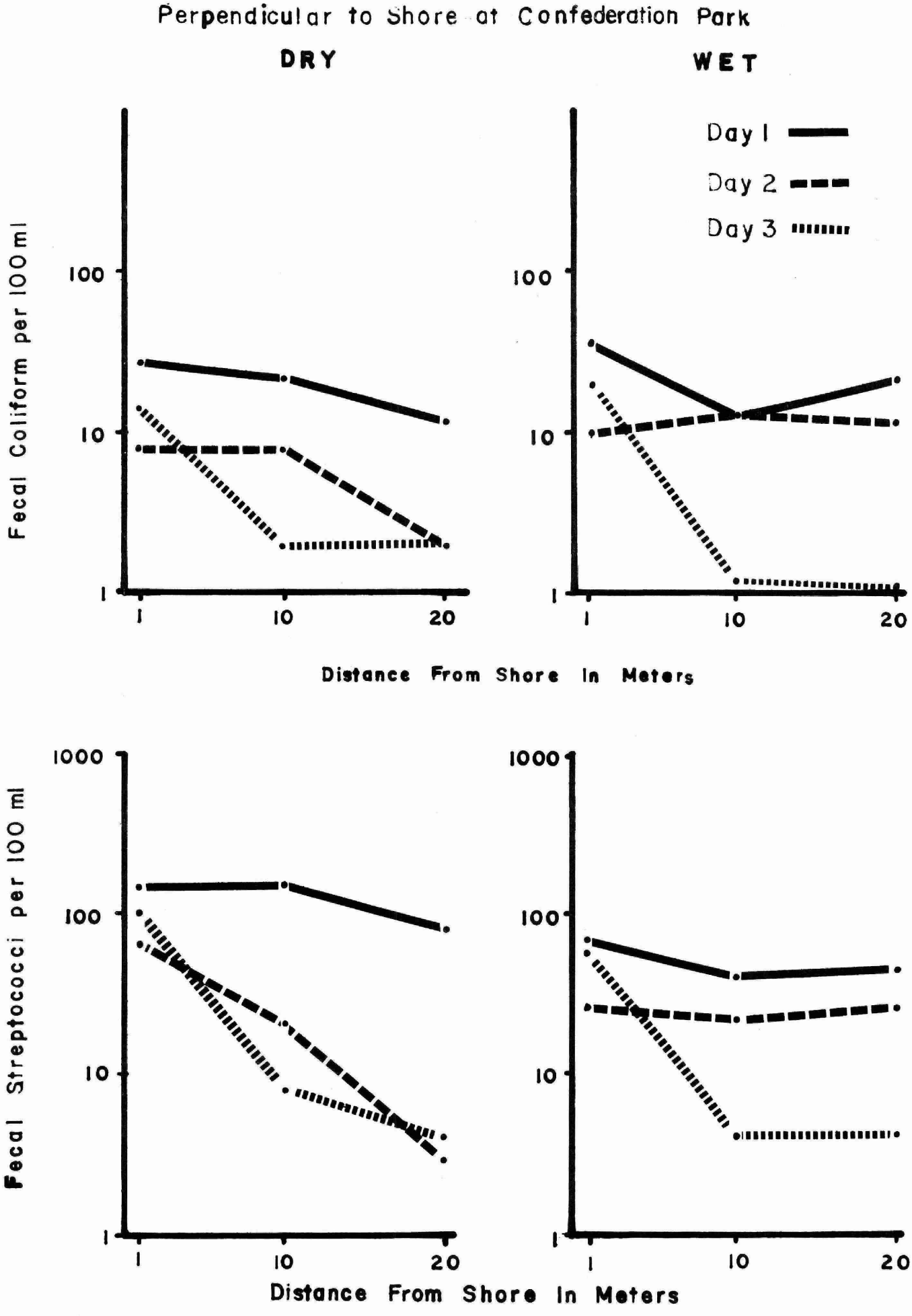
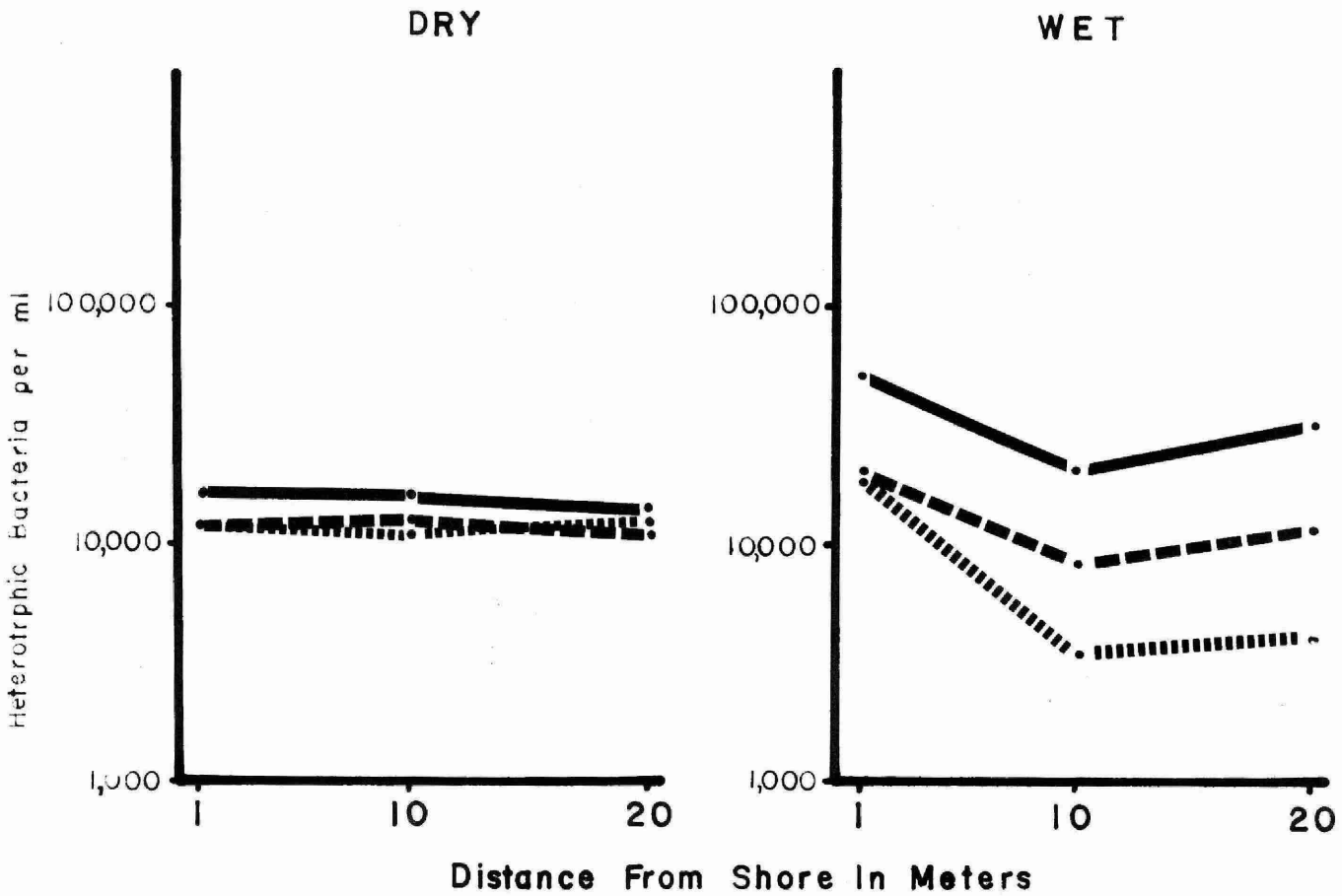

Microbial Population Densities
Perpendicular to Shore at Confederation Park
DRY
WET
Day 1
Day 2
Day 3
Fecal Coliform per 100 ml
100
10
1
1
10
20
Distance From Shore In Meters
Fecal Streptococci per 100 ml
1000
100
10
1
1
10
20
Distance From Shore In Meters

Figure 2.6

Microbial Population Densities
Perpendicular to Shore at Confederation Park



The August 22 set was somewhat more suitable having a measured rainfall of 4.6 mm in the early morning of day 1. Day 2 had a trace of rainfall recorded while day 3 had no precipitation recorded.

The Hamilton-Wentworth Regional Health Unit data for this period (Appendix 1) show some high levels (FC >100/100 mL) at four stations in the vicinity of Stoney Creek on day 1 with no high levels on days 2 or 3. The geometric mean for all transects of the August 23 run only are graphed in Figure 2.7. Both the Fecal Coliform and Fecal Streptococci populations show the following characteristics.

1. Initial high population density (FC = 57/100 ml, FS = 72/100 ml) on day 1. While these values are not exceedingly high, 2 of the 5 transects showed significantly high levels. For example, Hutchs' transect had fecal coliform densities of up to 300/100 mL and fecal streptococci populations of up to 750/100 mL. The transect at station 6 had fecal coliform levels in excess of 600/100 mL and fecal streptococci levels as great as 1040/100 mL.

2. During wet weather, bacterial populations do not appear to decline as rapidly with distance offshore as the samples during normal weather (dry) conditions (Fig. 2.5).

3. By day 3, both the Fecal Coliform and Fecal Streptococci levels have decreased by approximately an order of magnitude

   day 1 = 28 to 57/100 ml
   day 3 = 1 to 2/100 ml

Samples were also analysed for Pseudomonas aeruginosa during both wet and dry periods. Figure 2.8 shows the relative occurence of P. aeruginosa in the samples for the wet and dry periods. As this figure shows there is a marked tendency for the higher population densities of P. aeruginosa to occur following precipitation events. For example, the dry weather samples (n = 43) yielded only 4 samples having densities greater than 10 per 100 mL. The samples following precipitation events (n = 74) had 13 samples with densities greater than 10 per 100 mL. As the ratio of the total number of samples collected during wet and dry periods is 1.72:1.0 the observed ratio of 3.25:1.0 (73:43) of P. aeruginosa density greater than 10/100 mL would indicate increased levels following precipitation events.

Figure 2.7 Microbial Population Densities in Near Shore Lake Ontario Following The Aug. 22 Precipitation Event

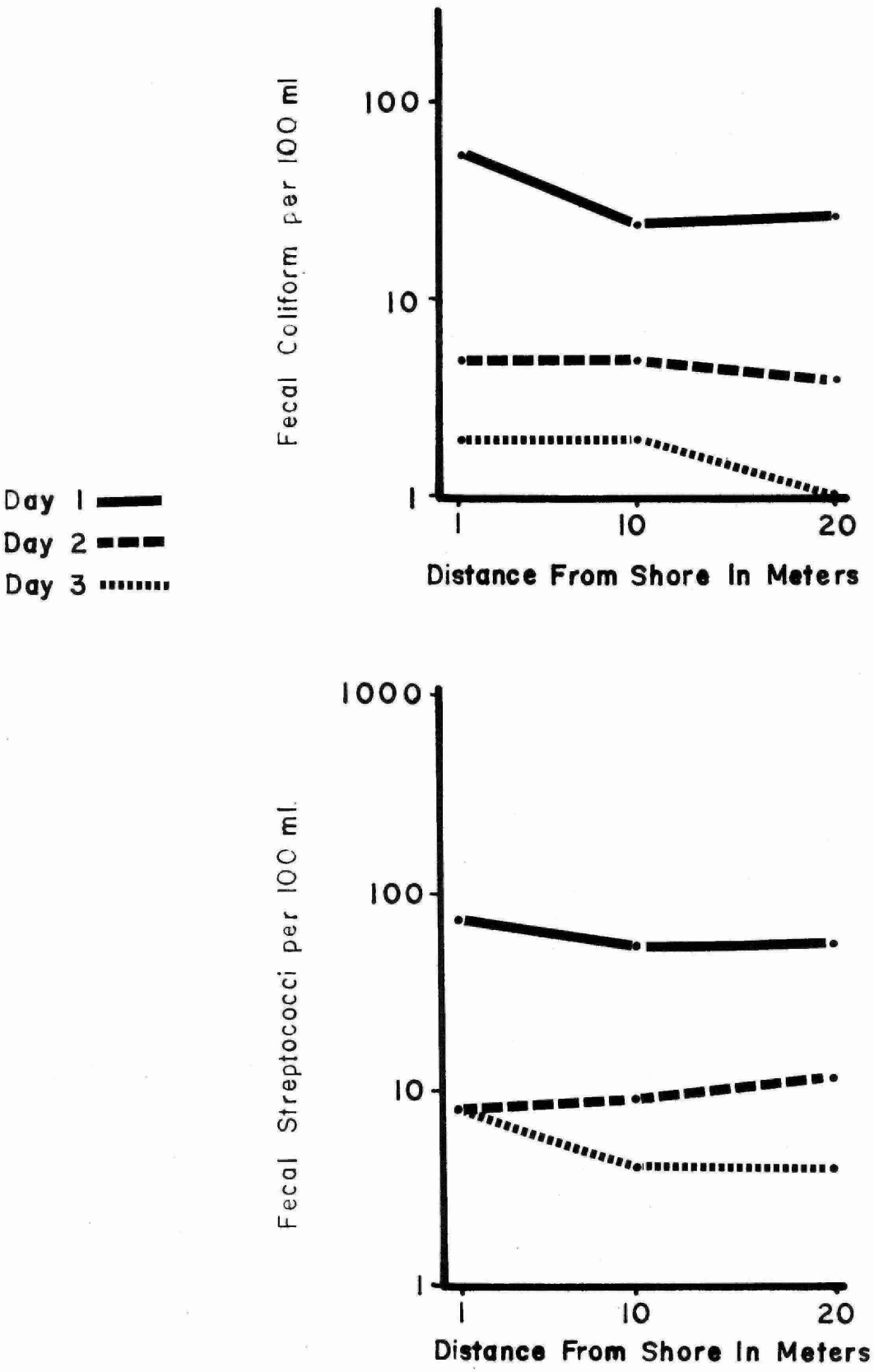
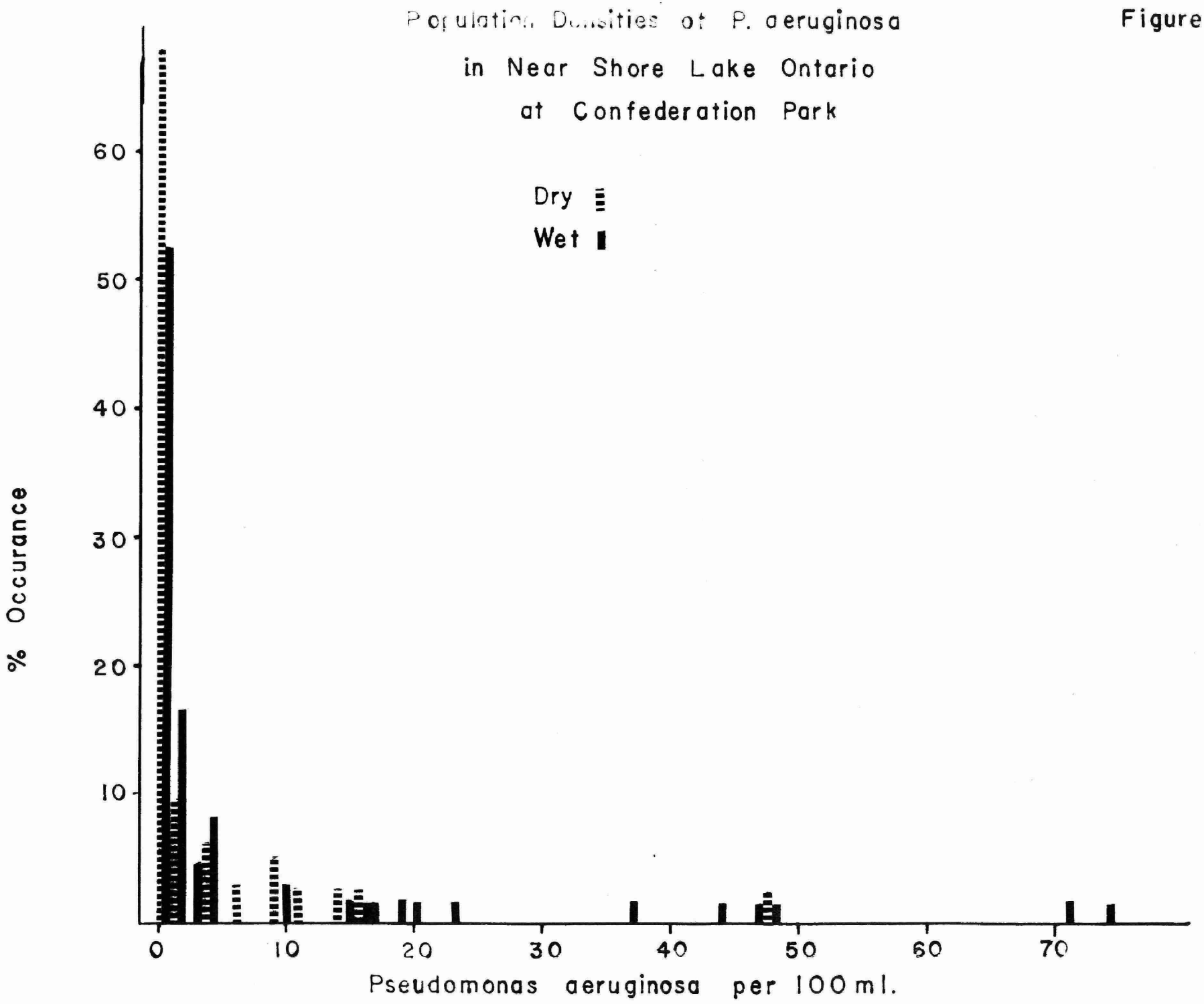


Figure 2.8


Population Densities of P. aeruginosa
in Near Shore Lake Ontario
at Confederation Park
Dry
Wet
% Occurance
60
50
40
30
20
10
0
10
20
30
40
50
60
70
Pseudomonas aeruginosa per 100 ml.

2.3 DISCUSSION

It has long been recognized that urban runoff, even in areas having completely separate sewer systems is highly contaminated with bacteria of various types. In fact, storm water microbial levels are similar to dilute sewage (Dutka and Rybakowski, 1978), and have high numbers of fecal coliform bacteria (10^2 to 10^5 per 100 mL). In areas having separate storm sewers, this pollution appears to be predominantly of non-human origin, and is mainly derived from animal waste (Qureshi, 1978).

In storm runoff from areas having combined sewers, total coliforms will be approximately 10 times the levels observed in areas having separate storm sewers. Also, combined sewers discharge contain about 40 times as many fecal coliforms as were detected in the separate storm sewer systems (Burns and Vaughan, 1966). This is due to the greater fraction of human waste in the combined sewer overflows.

Water infiltrating into storm sewers is also a source of continuous pollution during periods of no rainfall. Levels of bacteria in infiltration water can be on the order of 10^2 to 10^3 per 100 mL for Fecal and 10^3 to 10^7 for total coliforms (Dutka and Rybakowski, 1978). Urban streams are known to contain high levels of indicator bacteria during periods of no precipitation (Olivieri, 1977). This contamination may result from bacterial regrowth, started by contaminated sediment within the sewer system (Dutka and Rybakowski, 1978; Dutka and Tobin, 1978; Qureshi, 1978).

In light of the above, it is not surprising to find that the observed bacterial populations in near shore Lake Ontario in the Confederation Park area are related to runoff events. Stoney Creek, which discharges in the middle of the park area, had mean fecal coliform levels of 132/100 mL and fecal streptococci levels of 272/100 mL, and the storm sewer at station 6 had levels of FC = 2,470/100 mL and FS = 4,860/100 mL, following or during precipitation events. All of the inputs along the Lake Ontario lake front will carry some contamination as a result of runoff, but the above two are the closest to the main study area. The data provided by the Hamilton-Wentworth Regional Health Unit show numerous occasions when the nearshore Lake Ontario bacterial population are elevated following runoff events. The transect run following the slight rain on August 23 shows slightly elevated levels, decreasing by an order of magnitude over the next 48 hours.

The transect at station 6 showed the highest individual population density in Lake Ontario nearshore waters (FC = 600/100 mL and FS = 1040/100 mL). All of the above is consistant with sudden loadings from runoff following precipitation events.

It is interesting to examine the two occasions when the H.W.R.H.U. data (1979) shows elevated (FC 100/100 mL, FC 500/100 mL) levels that are not related to runoff events. It has been stated that increased numbers of indicator bacteria in shallow beach water may be caused by higher bather numbers in such waters (Foster et al, 1971). The three days preceding the June 18 event of this type were all extremely hot, having an average maximum temperature of 30.0°C (86°F) at the Mount Hope weather station. The five days preceding the July 17 event had an average maximum temperature of 30.5°C (87°F). The temperature in Hamilton, where most of the bathers would come from, would certainly be higher than those recorded at the weather station.

3.0 CONCLUSIONS

1. Incidents of high bacterial counts extending along the Lake Ontario shoreline (from the Burlington Canal to Fifty Point) are related to runoff following significant rainfall events.

2. On the two occasions during dry weather conditions, area-wide bacterial problems occurred immediately after prolonged periods (3 to 4 days) of abnormally high temperatures (maximum of about 30.0^{o}C). It has not been demonstrated whether these incidents are related to increased swimmer usage of the area during these unusually warm periods or some more complex temperature effects on the bacterial population dynamics.

3. The local effects of the poor water quality in Smith's Creek are very pronounced in nearshore Lake Ontario around McNeilly and Winona Roads. This effect does not appear to extend beyond this area.

4. Following a significant runoff event, bacterial populations in the near-shore (less than 20 meters off shore) Lake Ontario are elevated, but decrease by an order of magnitude in the following 24 to 48 hours.

5. Following periods of slight rainfall (i. e. trace or 1 - 2 ml) which does not produce significant runoff events, bacterial populations were elevated in Lake Ontario in the vicinity of the large inputs (Stoney Creek, and storm sewer No. 6).

REFERENCES

Burm R. J., Vaughan R. D., 1966: Bacteriological Comparison between combined and separate sewer dischargers in Southwestern Michigan. Jour. Water Pollut. Control Fed. Vol. 38 pp. 400-409

Dutka B. J., Tobin S., 1978: Monitoring of Storm Water Runnoffs for Bacterial and Viral Pathogens of Man. In Environment Canada Research Report No. 82

Dutka, B.J., Rybakowski I., 1978: Microbiological Study of Some Canadian Storm Water Runoffs at Burlington and Brucewood. In Environment Canada, Research Report No. 87.

Foster D.M., Hanes N.B., Lord S.M., 1971: A Critical Examination of Bathing Water Quality Standards Jour. Water Pollut. Control Fed. Vol. 42, pp 2229-2241

Hoadley A.W., 1967: The Occurance and Behaviour of Pseudomonas aeruginosa in Surface Waters, Unpublished Ph.D. Thesis, U. of Wisconsin

MOE, 1978: Outline of Microbiological Methods, M. Young, Microbiology Section, Laboratory Services

Olivieri V.P. et al 1971: Microganisms in Urban Stormwater, U.S. EPA /600/ 2/77/087, Cincinnati, Ohio

Qureshi A.A., 1978: Microbiological Characteristics of Storm Water Runoffs at East York (Toronto) and Guelph Separate Storm Sewers. Environment Canada Research Report No. 87

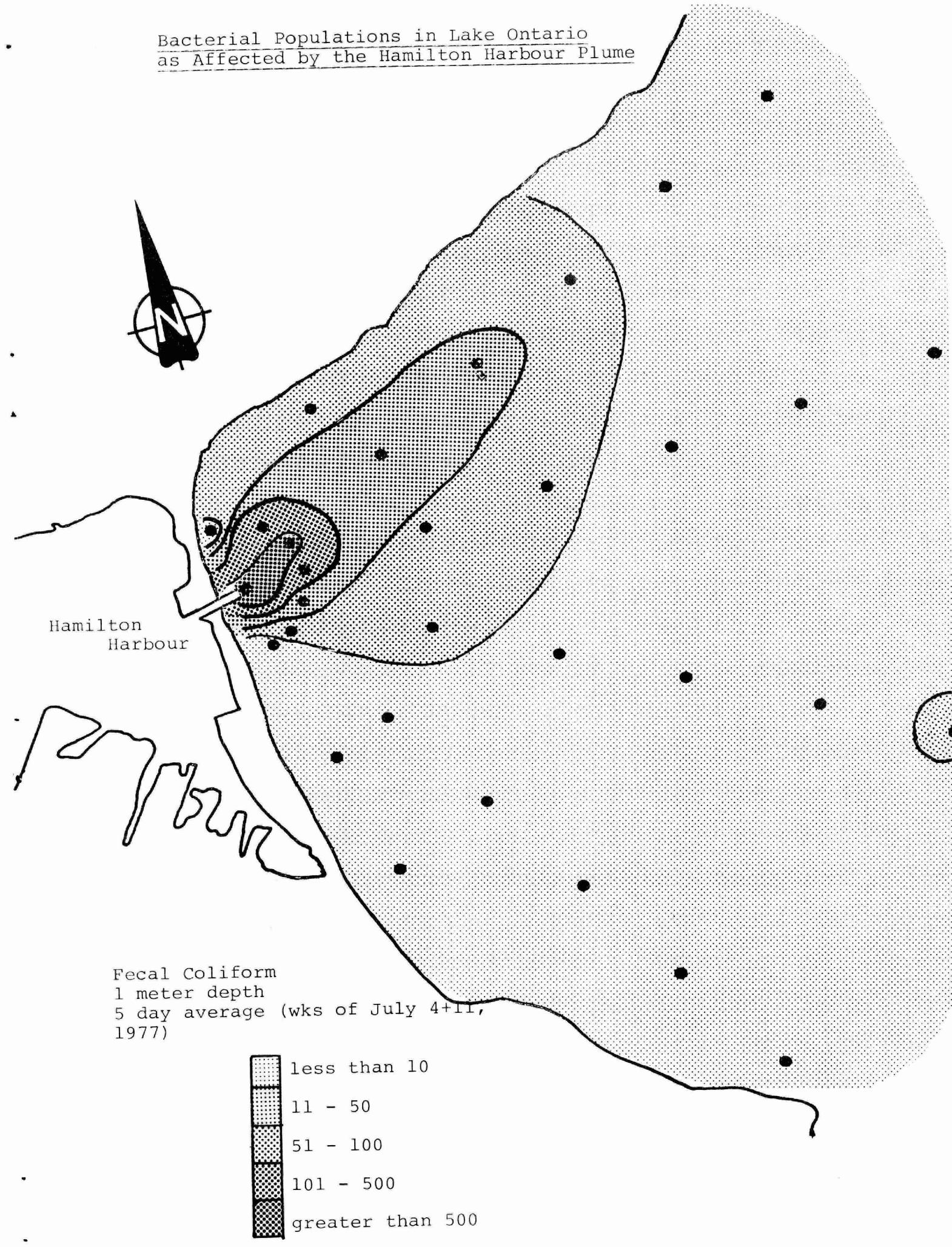
Rao, S.S., Jurkovic A.A., 1967: Differentiation of the Trophic Status of the Great Lakes By Means of a Bacterial Index Ratio. Jour. Great Lakes Reserach 1, Vol. 3, pp 323-326

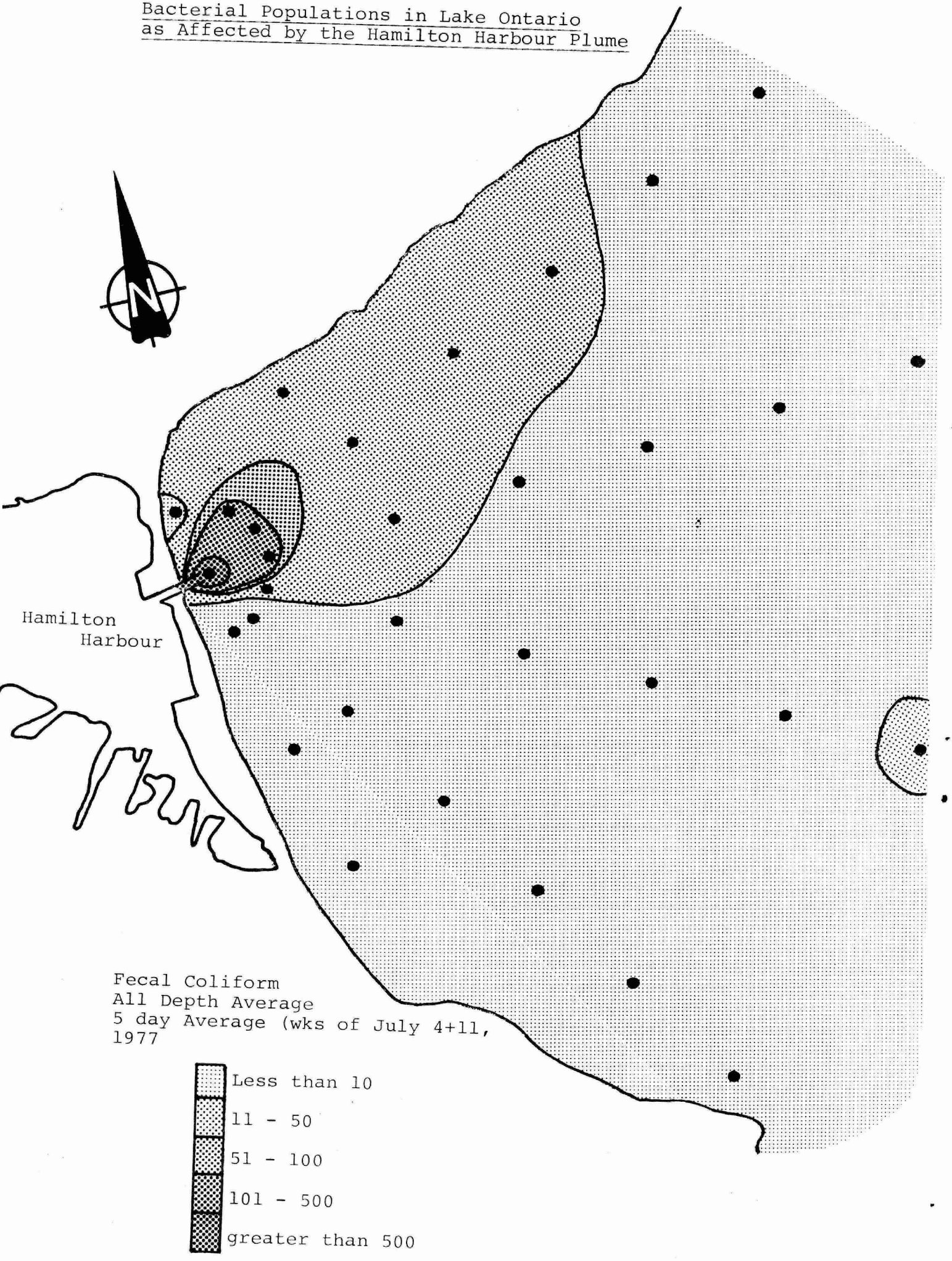
Sherry J.P., Kuchma S.R., Zarzour J., Dutka B.J., 1979: Occurance and Significance of Candida albicans in Lake Ontario Bathing Beacher, Environment Canada, Scientific Series No. 98

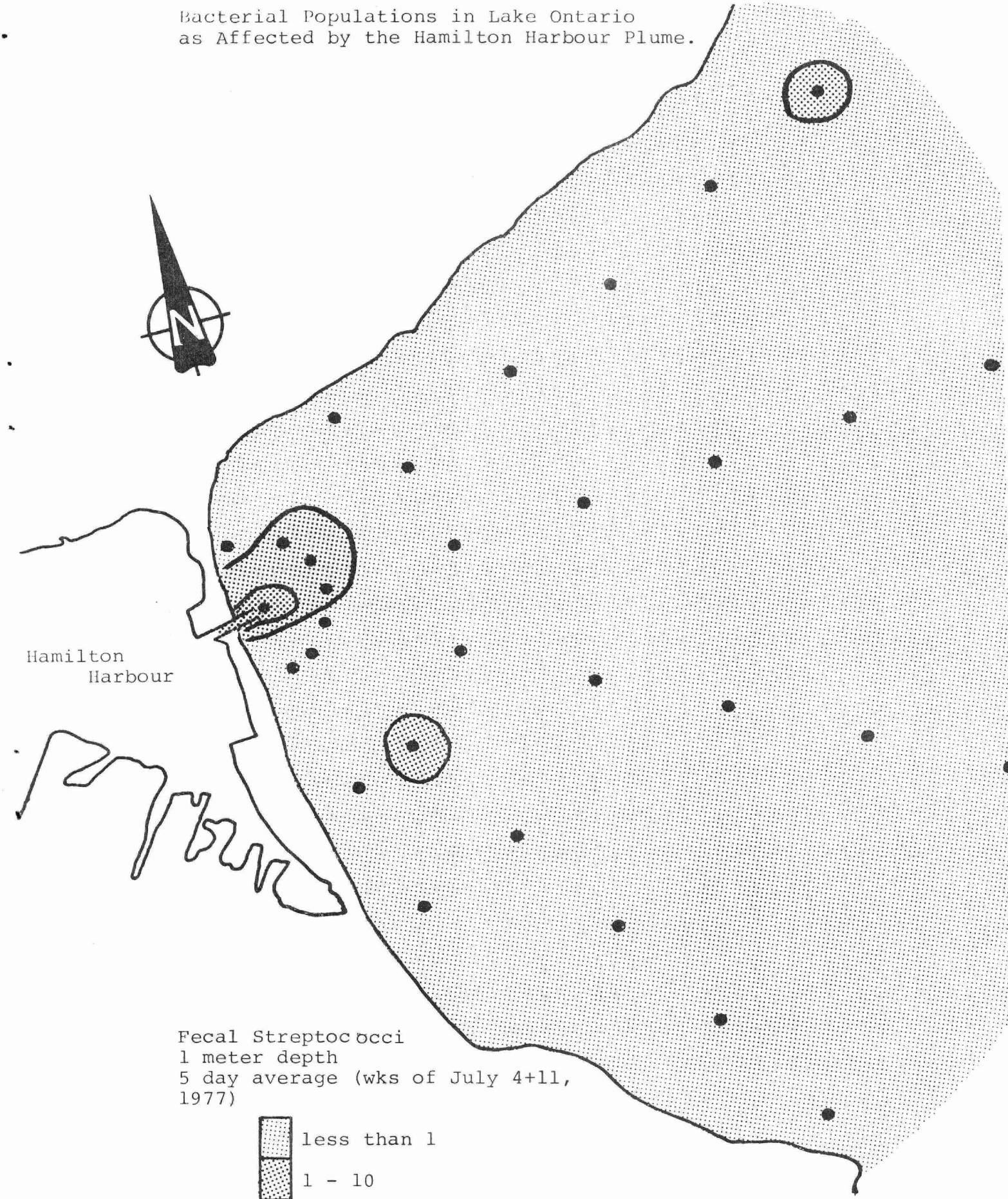
Appendix I

Hamilton Harbour Bacterial Plume (CCIW Data)

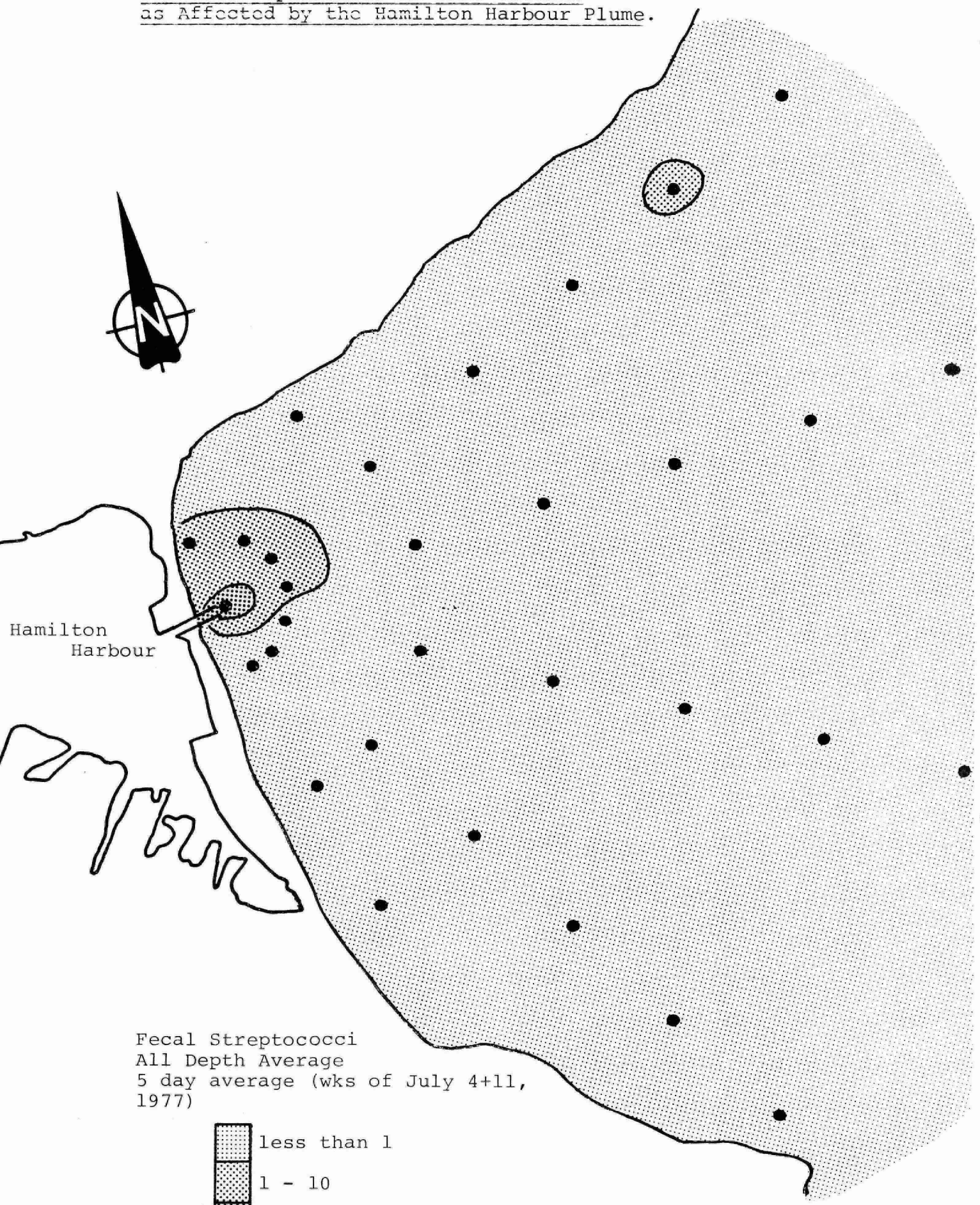
Bacterial Populations in Lake Ontario
as Affected by the Hamilton Harbour Plume




Bacterial Populations in Lake Ontario
as Affected by the Hamilton Harbour Plume
N
Hamilton
Harbour
Fecal Coliform
All Depth Average
5 day Average (wks of July 4+11,
1977
Less than 10
11 - 50
51 - 100
101 - 500
greater than 500


Bacterial Populations in Lake Ontario
as Affected by the Hamilton Harbour Plume.
N
Hamilton
Harbour
Fecal Streptococci
1 meter depth
5 day average (wks of July 4+11,
1977)
less than 1
1 - 10
11 -50

Bactrial Populations in Lake Ontario
as Affected by the Hamilton Harbour Plume.

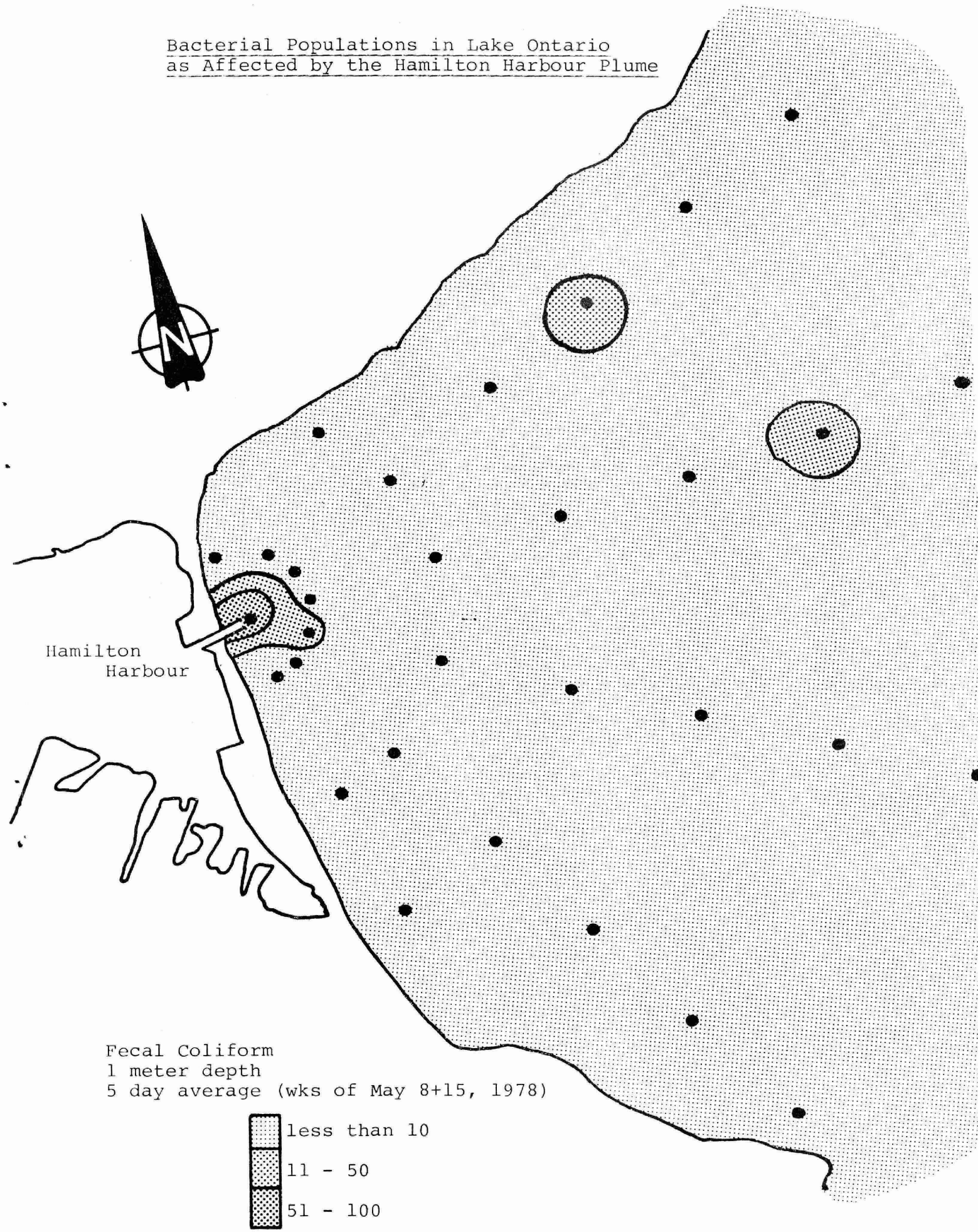


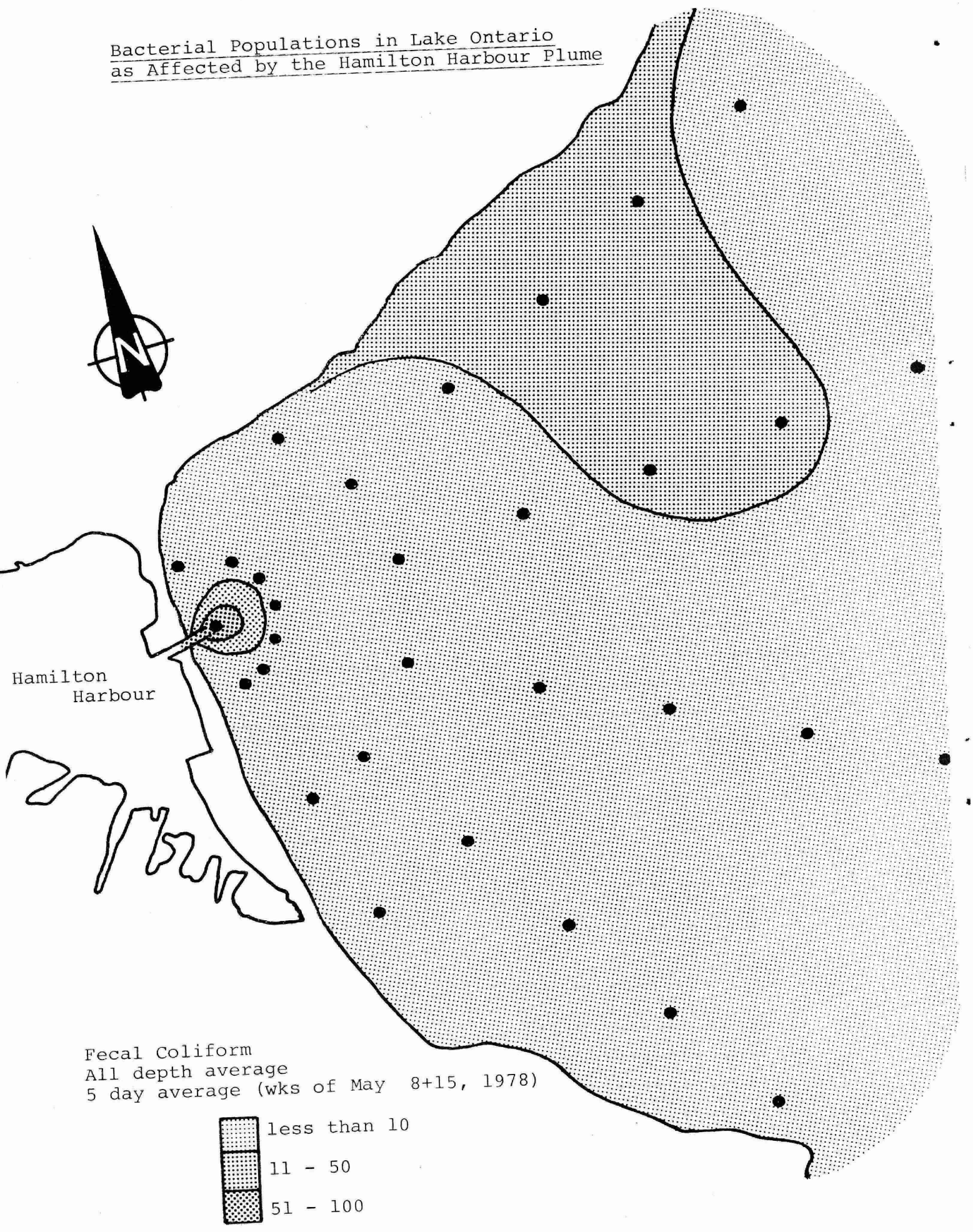
Fecal Streptococci
All Depth Average
5 day average (wks of July 4+11, 1977)

less than 1

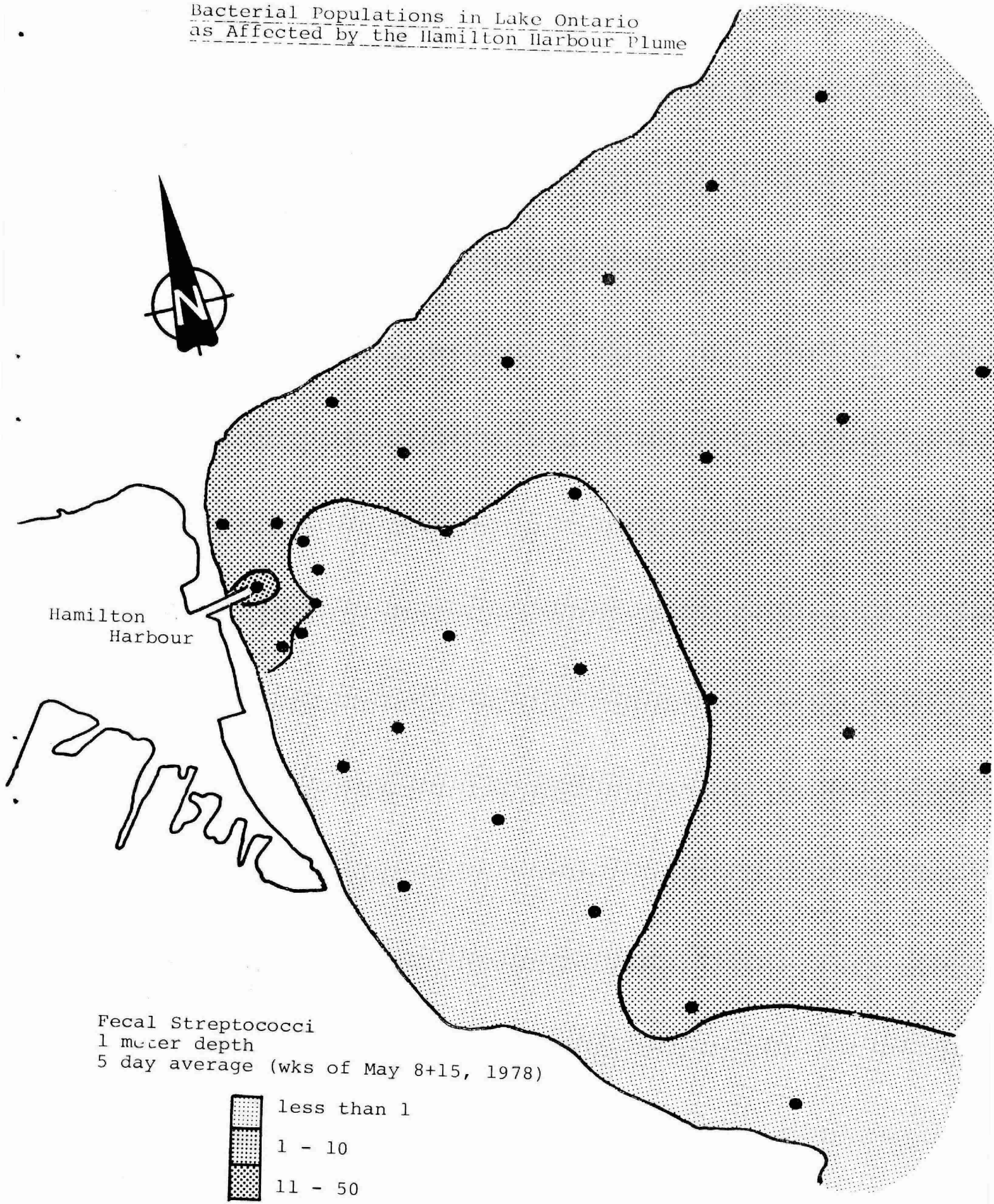
1 - 10

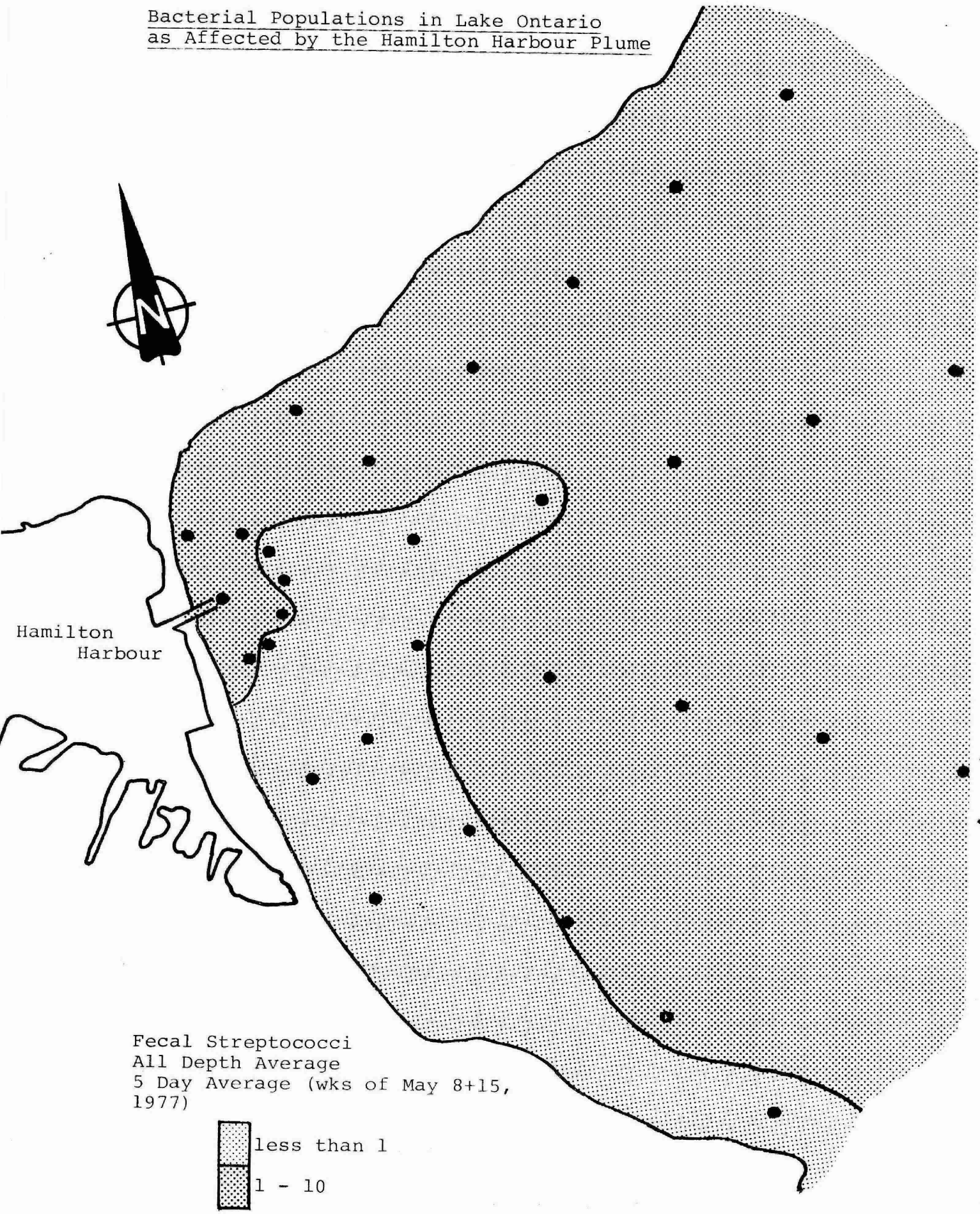
11 - 50


Bacterial Populations in Lake Ontario
as Affected by the Hamilton Harbour Plume
N
Hamilton
Harbour
Fecal Coliform
1 meter depth
5 day average (wks of May 8+15, 1978)
less than 10
11 - 50
51 - 100

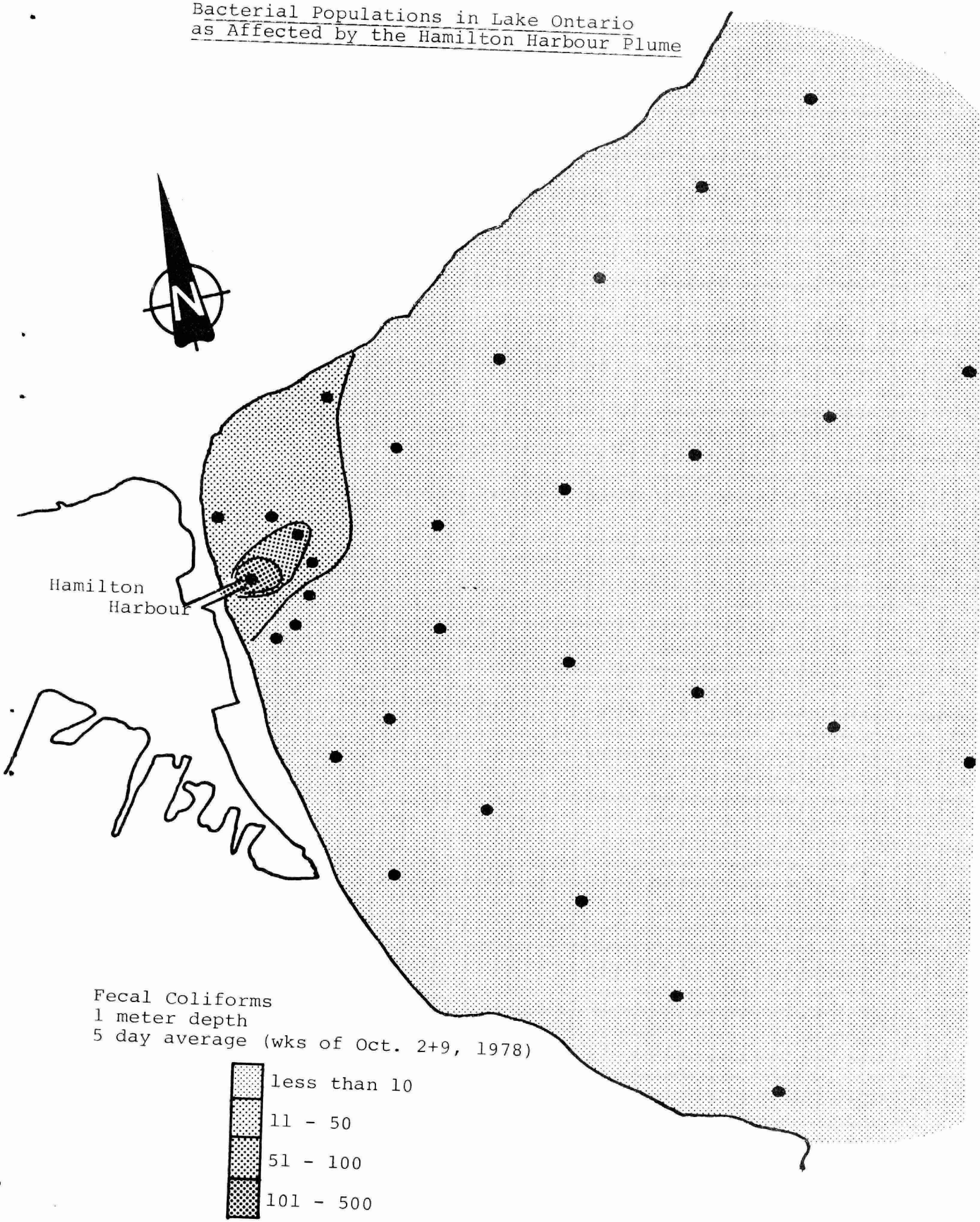

Bacterial Populations in Lake Ontario
as Affected by the Hamilton Harbour Plume
N
Hamilton
Harbour
Fecal Coliform
All depth average
5 day average (wks of May 8+15, 1978)
less than 10
11 - 50
51 - 100

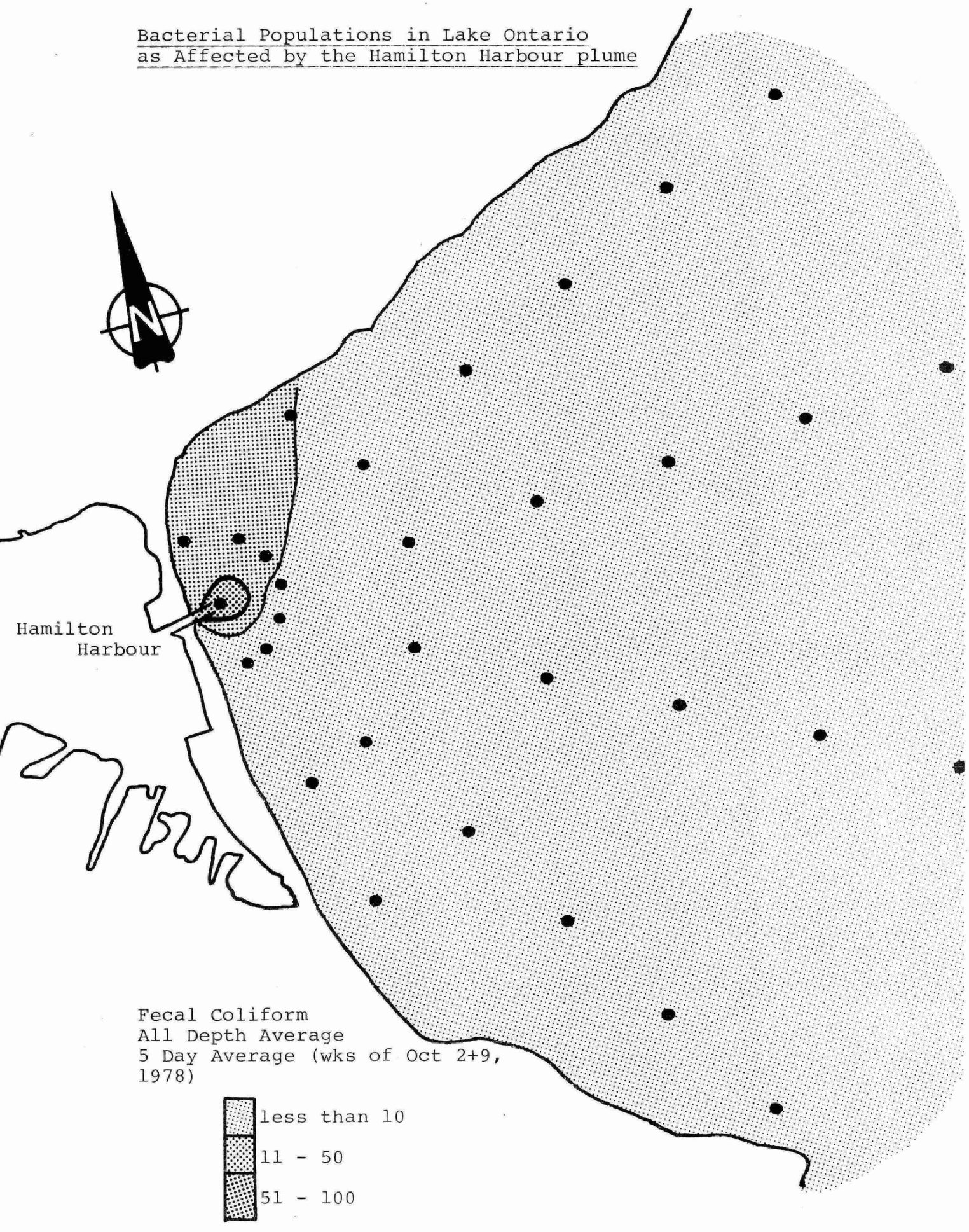
Bacterial Populations in Lake Ontario
as Affected by the Hamilton Harbour Plume



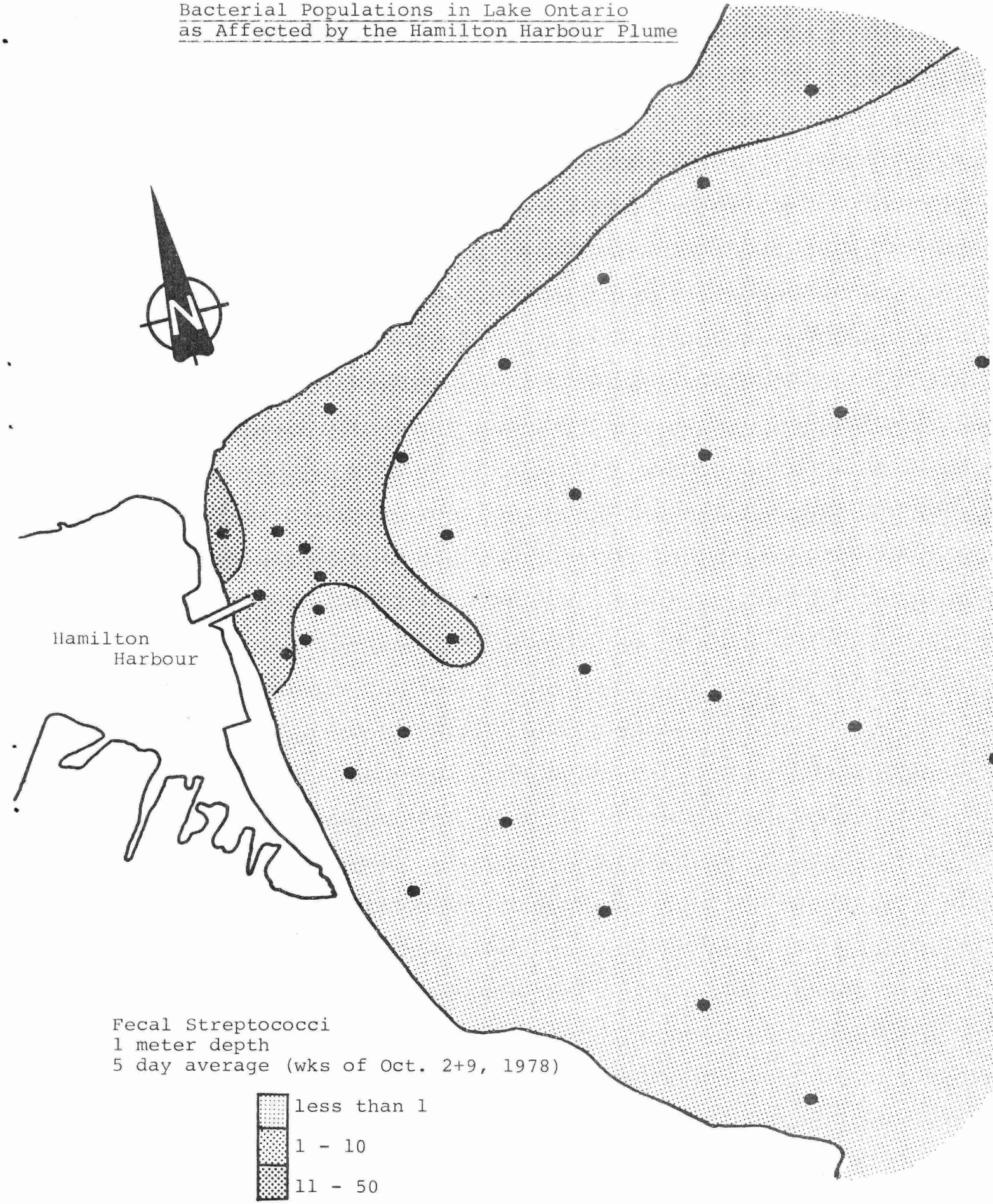

Bacterial Populations in Lake Ontario
as Affected by the Hamilton Harbour Plume
N
Hamilton
Harbour
Fecal Streptococci
All Depth Average
5 Day Average (wks of May 8+15,
1977)
less than 1
1 - 10

Bacterial Populations in Lake Ontario
as Affected by the Hamilton Harbour Plume

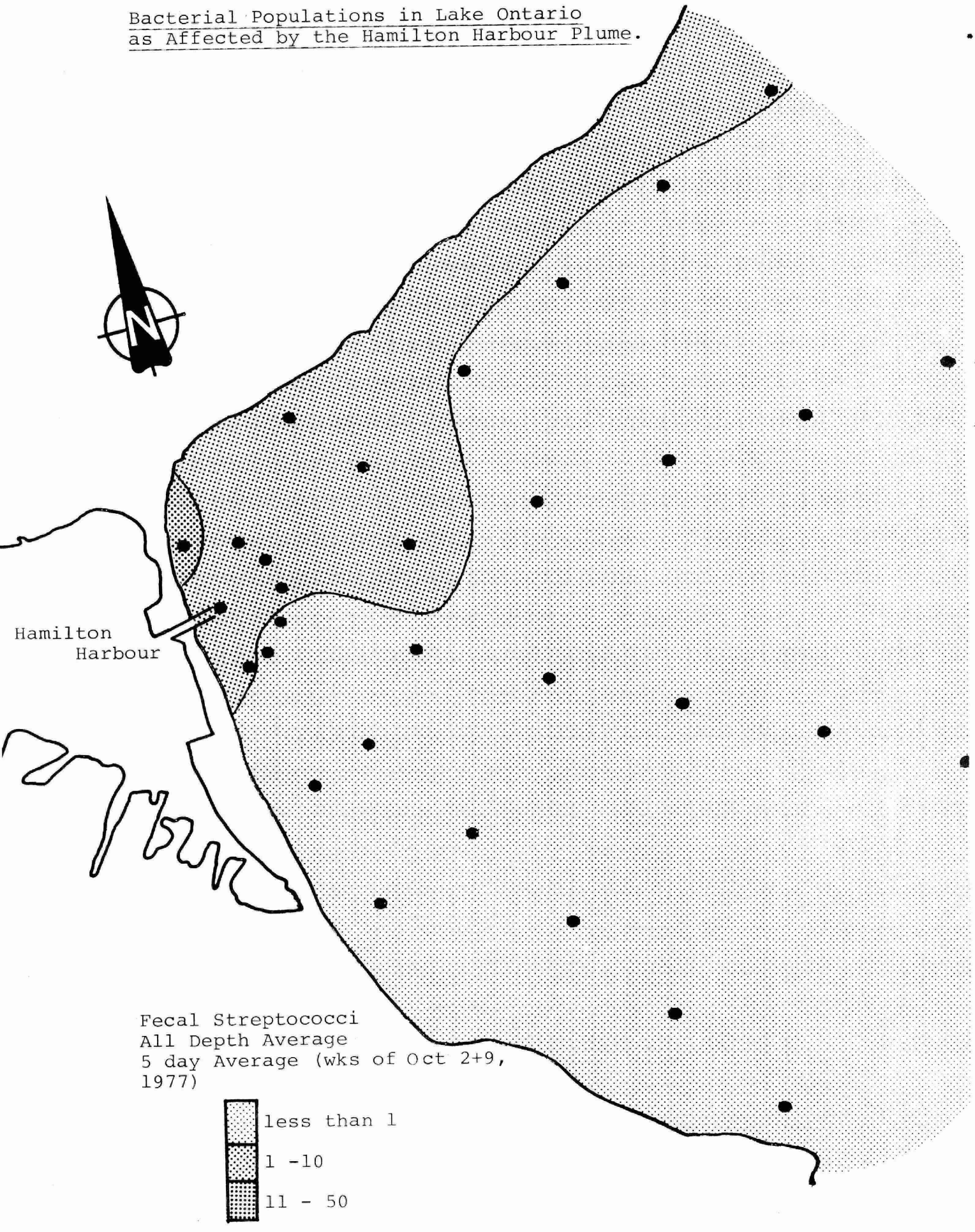



Bacterial Populations in Lake Ontario
as Affected by the Hamilton Harbour plume
N
Hamilton
Harbour
Fecal Coliform
All Depth Average
5 Day Average (wks of Oct 2+9,
1978)
less than 10
11 - 50
51 - 100

Bacterial Populations in Lake Ontario
as Affected by the Hamilton Harbour Plume



Bacterial Populations in Lake Ontario
as Affected by the Hamilton Harbour Plume.



Appendix 2

Hamilton-Wentworth Regional Health Unit Data (1979)

HAMILTON REGIONAL HEALTH UNIT BACTERIOLOGICAL DATA 1979

WEEK OF: June 10 -16 1979

STATION	11 TC	11 FC	12 TC	12 FC	13 TC	13 FC	14 TC	14 FC	15 TC	15 FC	16 TC	16 FC
1. Ship Canal			120	20	10	<10	10	10	20	20	<10	<10
2. Killarney Avenue												
3. Concession Stand			220	20	120	<10	100	50				
4. Marine Dock			130	80	200	20	90	20	<10	<10	20	<10
5. W. Confederation Park			210	210	20	<10	10	<10	<10	<10	<10	<10
5c. Change House			[illegible]		[illegible]		[illegible]	<10	<10	<10	20	20
5d. E. Confederation Park			130	20	60	20	10	<10	<10	<10	10	<10
6. Grays Road			60	50	50	<10	20	<10	30	20	20	<10
7. Greens Road			50	<10	20	20	10	<10	10	<10	30	10
8. Cherry Beach			140	70	250	20	20	20	290	40	120	80
9. Fruitland Road			160	30	250	50	40	<10	30	10	150	90
10. McNeilly Road			2100	250	2500	120	30	<10	110	30	2500	1100
11. Winona Road			260	80	220	10	30	20	100	30	80	40
12. Smiths Creek											2000	900
Daily Precipitation	Trace											
Average Wind Speed and Direction	24.5 WSW		16.5 WNW		14.5 W		16 ∠ SSW		24 / SW		16.2 W	
Maximum Wind Speed and Direction	41 NW		24 NNW		26 W		28 S		39 WSW		31 W	

HAMILTON REGIONAL HEALTH UNIT BACTERIOLOGICAL DATA 1979

WEEK OF: June 17 - 23

STATION	17	18 TC	18 FC	19 TC	19 FC	20 TC	20 FC	21 TC	21 FC	22 TC	22 FC	23 TC	23 FC
1. Ship Canal		3900	2,300	50	<10	170	40	240	30	240	40	200	100
2. Killarney Avenue													
3. Concession Stand						60	10	70	10	<10	<10	30	30
4. Marine Dock		2,300	150	<10	<10	<10	<10	120	10	70	50	40	10
5. W. Confederation Park		600	100	10	<10	220	180	140	60	40	<10	130	40
5c. Change House		1,300	570	10	<10	60	60	100	<10	10	10	70	50
5d. E. Confederation Park		2,100	300	10	<10	340	220	80	40	40	<10	70	10
6. Grays Road		600	460	20	10	40	<10	70	<10	30	20	110	20
7. Greens Road		5,300	5,300	20	<10	10	<10	280	20	<10	<10	90	90
8. Cherry Beach		>8,000	>8,000	20	10	280	10	115	20	50	40	280	70
9. Fruitland Road		>8,000	>6,000	50	10	20	<10	130	30	100	40	100	100
10. McNeilly Road		3,000	5,500			50	30	70	10	70	<10	480	130
11. Winona Road		>8000	>6000	1800	50	>8000	3700	>8000	900	130	30	800	800
12. Smiths Creek						270	140			>8000	5700	200	90
Daily Precipitation								7:00 → 12:30		8:10 → 9:45			
								0.4 mm		0.8 mm		Trace	
Average Wind Speed and Direction	19.2 SSW	15.5 E		15.7 ENE		18.4 SSE		20.4 SSW		20.0 WNW		22.4 W	
Maximum Wind Speed and Direction	33 SW	20 ENE		26.0 ENE		30 SSE		26.0 S		33.0 W		28 W	

HAMILTON REGIONAL HEALTH UNIT BACTERIOLOGICAL DATA 1979

WEEK OF: June 24 - 30

STATION		24 TC	24 FC	25 TC	25 FC	26 TC	26 FC	27 TC	27 FC	28 TC	28 FC	29 TC	29 FC	30 TC	30 FC
1. Ship Canal				80	30	<10	<10	<10	<10	150	150	270	100	1000	700
2. Killarney Avenue															
3. Concession Stand				50	20	20	20	<10	<10	1300	340	1600	180	1000	600
4. Marine Dock				80	<10	<10	<10	10	<10	1200	160	800	70	700	600
5. W. Confederation Park				190	40	<10	<10	10	10	>8000	3,600	1300	900	1000	600
5c. Change House				<10	<10	<10	<10	<10	<10	>8000	3,200	2,800	70	500	100
5d. E. Confederation Park				50	20	<10	<10	10	<10	>8000	3,400	2,600	900	320	140
6. Grays Road				30	<10	10	<10	10	<10	70	70	220	30	<50	60
7. Greens Road				70	20	350	20	10	<10	2,200	700	200	20	500	100
8. Cherry Beach				20	10	60	10	10	<10	300	270	160	10	4100	200
9. Fruitland Road				20	10	10	<10	40	<10	>8000	700	160	50	130	40
10. McNeilly Road				10	10	<10	<10	50	30	70	40	500	100	1600	220
11. Winona Road				2800	250	300	240	600	100	>8000	1700	78000	3,400	78000	3,800
12. Smiths Creek				700	350	2500	1,100	110	10	>8000	>6000	2800	510	78000	3,700
Daily Precipitation	Trace							15:30 → 20:25 12.4 mm		0 → 6:00 10.0 mm		17:00 → 10:50 5.2		0:00 → 24:00 19.2	
Average Wind Speed and Direction	15.6 N			17.7 SSW		13.4 SSW		18.6 SSW		9.3 S		8.7 NE		13.8 E	
Maximum Wind Speed and Direction	22.0 NW			22 SSE		30.0 SSW		37.0 SSW		19 NW		19 NE		17.0 SE	

HAMILTON REGIONAL HEALTH UNIT BACTERIOLOGICAL DATA 1979

WEEK OF: July 1 - 7

STATION		2 TC	2 FC	3 TC	3 FC	4 TC	4 FC	5 TC	5 FC	6 TC	6 FC	7 TC	7 FC
1. Ship Canal		280	60							10	<10	70	70
2. Killarney Avenue													
3. Concession Stand		20	20							160	160	40	40
4. Marine Dock		10	10							10	10	40	40
5. W. Confederation Park		140	140							10	<10	20	<10
5c. Change House		290	10							18	1	60	10
5d. E. Confederation Park		40	40							10	10	60	10
6. Grays Road										18	18	70	10
7. Greens Road		150	40							90	40	20	10
8. Cherry Beach		2400	10							20	<10	50	50
9. Fruitland Road		270	40							10	<10	60	10
10. McNeilly Road		50	10							30	<10	40	40
11. Winona Road		330	40							<10	<10	210	70
12. Smiths Creek		1700	700							310	310		
Daily Precipitation	3.2	3:00 → 10:30 0.9											
Average Wind Speed and Direction	15.7 S	17.5 WNW		16.9 W		12.3 NNW		18.0 SSW		13.8 W		8.1 SSW	
Maximum Wind Speed and Direction	26 S	30.0 NW		26.0 W		28.0 NNW		30.0 NNW		19.0 13.8		15.0 SW	

HAMILTON REGIONAL HEALTH UNIT BACTERIOLOGICAL DATA 1979

WEEK OF: July 8 - 14

STATION		9 TC	9 FC	10 TC	10 FC	11 TC	11 FC	12 TC	12 FC	13 TC	13 FC	14 TC	14 FC
1. Ship Canal		180	160	180	180	2100	1700	40	0	760	620	210	210
2. Killarney Avenue						30	10					30	<10
3. Concession Stand		20	<10	130	60	80	80	350	130	10	<10	280	130
4. Marine Dock		40	20	40	10	10	10	260	230	30	10	320	210
5. W. Confederation Park		50	50	40	20	210	20	240	210	20	10	230	230
5c. Change House		250	180	30	<10	70	50	150	80	20	10	300	300
5d. E. Confederation Park		190	130	20	20	60	40	20	20	10	10	240	240
6. Grays Road		30	10	20	20	10	<10	20	20	40	40	160	160
7. Greens Road		40	40	30	20	7000	800	10	<10	1000	140	160	160
8. Cherry Beach		40	30	40	20	10	10	10	<10	10	<10	210	150
9. Fruitland Road		10	<10	30	10	60	<10	40	30	10	<10	150	150
10. McNeilly Road		10	10	30	<10	70	<10	70	30	210	80	40	20
11. Winona Road		190	50	2700	1700	3500	800	170	30			7000	1600
12. Smiths Creek		320	180	210	30	110	50	400	280			440	240
Daily Precipitation		16 00 → 20 10		17 10 → 18 10		15 20 → 15 30							
		1.2 mm		5.2 mm		0.2 mm							
Average Wind Speed and Direction	8.5 SW1	7.5 NE		13.7 SSE		11.0 WSW		9.1 W		9.0 NE		9.2 SSW	
Maximum Wind Speed and Direction	15.0 S	17.0 SSW		26.0 S		22.0 S		17.0 SSW		19.0 NE		SW 15.0	

HAMILTON REGIONAL HEALTH UNIT BACTERIOLOGICAL DATA 1979

WEEK OF: July 15 - 21

STATION	15	16 TC	16 FC	17 TC	17 FC	18 TC	18 FC	19 TC	19 FC	20 TC	20 FC	21 TC	21 FC
1. Ship Canal		170	170	2,300	1,600	120	120	20	20	50	30	20	10
2. Killarney Avenue		10	10	420	370	160	90	10	10	100	90	80	80
3. Concession Stand		60	30	360	250	140	140	540	540	170	170	30	10
4. Marine Dock		<10	<10	700	600	80	30	10	10	30	20	<10	<10
5. W. Confederation Park		90	90	2,300	600	120	90	20	<10	60	60	80	20
5c. Change House		30	10	3,300	2,500	170	50	20	10	30	30	30	30
5d. E. Confederation Park		60	30	1,500	1,300	80	70	60	60	60	50	10	10
6. Grays Road		80	30	370	370	60	30	30	10	50	40	20	20
7. Greens Road		170	90	1400	400	60	60	30	30	30	20	<10	<10
8. Cherry Beach		20	10			40	40	20	20	110	110	<10	<10
9. Fruitland Road		70	20	370	50	100	50	100	30	70	20	80	<10
10. McNeilly Road		40	20	950	650	30	10	10	10	<10	<10	370	240
11. Winona Road		1300	450	1200	220	1,700	350	530	700	300	80	120	20
12. Smiths Creek		3,900	2,300			2,000	2,000	>2,000	900				
Daily Precipitation													
Average Wind Speed and Direction	11.3 WNW	9.9 WNW		14.6 SSW		8.3 NW		9.5 W		8.4 SW		8.4 SSW	
Maximum Wind Speed and Direction	26.0 W	24.0 NNW		26.0 NE		15.0 NNW		19.0 S		11.0 SW		17.0 SSW	

HAMILTON REGIONAL HEALTH UNIT BACTERIOLOGICAL DATA 1979

WEEK OF: July 22 - 28

STATION	22	23 TC	23 FC	24 TC	24 FC	25 TC	25 FC	26 TC	26 FC	27 TC	27 FC	28 TC	28 FC
1. Ship Canal		40	40	30	30	20	20	200	<10	430	300	120	70
2. Killarney Avenue		10	10	50	50	10	10	20	<10	50	50	80	20
3. Concession Stand		30	30	60	60	40	40	130	90	130	110	80	40
4. Marine Dock		10	10	80	80	30	30	200	190	780	500	90	90
5. W. Confederation Park		20	20	30	20	70	<10	380	380	400	300	30	10
5c. Change House		30	30	40	20	10	<10	370	370	300	300	60	10
5d. E. Confederation Park		270	270	30	30	70	70	340	340	1000	700	80	30
6. Grays Road		20	20	60	60	50	50	>8000	24,000	310	310	40	30
7. Greens Road		<10	<10	100	100	40	40	180	190	70	70	100	100
8. Cherry Beach		50	50	50	40	80	<10	160	160	60	40	70	70
9. Fruitland Road		<10	<10	210	210	120	120	320	360	30	10	50	50
10. McNeilly Road		3500	3,500	720	220	240	250	1300	300	650	410	2,700	1,600
11. Winona Road				50	50	140	110	210	200	110	110	78,000	76,000
12. Smiths Creek		>8,000	>6,000					>8,000	4,500				
Daily Precipitation						18.00 → 20:15						8:00 → 16.30	
						20.9						2.2	
Average Wind Speed and Direction	11.5 SSW	9.3 SSW		17.1 SW		20.8 SSW		18.8 WNW		5.5 SW		12.9 SW	
Maximum Wind Speed and Direction	20.0 WNW	17.0 SSW		30.0 SW		37.0 SW		30.0 WNW		11.0 NW		30.0 SW	

HAMILTON REGIONAL HEALTH UNIT BACTERIOLOGICAL DATA 1979

WEEK OF: July 29 - Aug 4

STATION	29	30 TC	30 FC	31 TC	31 FC	1 TC	1 FC	2 TC	2 FC	3 TC	3 FC	4 TC	4 FC
1. Ship Canal		420	420	30	<10	240	180	350	300	40	40	100	90
2. Killarney Avenue				10	10	300	100	420	160	50	50	20	20
3. Concession Stand		60	60	420	200	110	90	110	100	40	40	20	10
4. Marine Dock		<10	<10	50	40	170	60	140	130	30	10	20	10
5. W. Confederation Park		<10	<10	110	80	1,300	1,100	350	300	10	10	70	70
5c. Change House		20	20	20	10	190	160	340	290	50	50	20	10
5d. E. Confederation Park		10	<10	40	30	160	120	360	200	20	20	30	30
6. Grays Road		<10	<10	30	<10	80	40	220	130	120	120	70	70
7. Greens Road		60	60	40	20	150	40	220	220	150	150	100	40
8. Cherry Beach		20	20	560	420	80	70	1,300	1,300	20	20	110	30
9. Fruitland Road		10	10	480	430	70	50	500	500	100	50	60	20
10. McNeilly Road				50	50	270	200	700	380	100	100	50	50
11. Winona Road		420	420	60	50	7,000	7,000	23,000	0.6	130	130	100	100
12. Smiths Creek		7,000	7,000			>3,000	>3,000						
Daily Precipitation		21:00 → 24:00		13:10 → 18:00		1:00 → 24:00		0:00 → 12:20					
		3.2 mm		8.0 mm		3.0 mm		23.2 mm		Trace			
Average Wind Speed and Direction	6.6 NW	11.2 SW		15.3 SSW		11.9 ENE		17.8 W		13.7 SW		11.4 SSW	
Maximum Wind Speed and Direction	11.0 ENE	20.0 S		22.0 SSW		19.0 NE		37.0 W		33.0 WSW		20.0 WSW	

HAMILTON REGIONAL HEALTH UNIT BACTERIOLOGICAL DATA 1979

WEEK OF: Aug 5 - 11

STATION	5	6		7		8		9		10		11	
		TC	FC	TC	FC	TC	FC	TC	FC	TC	FC	TC	FC
1. Ship Canal				100	50	30	20	60	40	60	60	150	100
2. Killarney Avenue				110	10	10	<10	40	40	70	70	320	270
3. Concession Stand				130	40	20	20	20	20	270	120	20	<10
4. Marine Dock				80	40			80	60	180	170	20	20
5. W. Confederation Park				20	20	2300	2200	80	60	110	110	160	20
5c. Change House				90	30	40	20	380	340	240	240	20	10
5d. E. Confederation Park				90	40	30	30	260	190	230	220	70	40
6. Grays Road				30	<10	30	30	110	110	50	30	10	10
7. Greens Road				30	10	30	10	20	20	60	60	30	20
8. Cherry Beach				70	10	50	20	20	20	160	140	20	<10
9. Fruitland Road				30	10	70	50	120	30	110	80	20	10
10. McNeilly Road				70	40	130	60	1600	1600	160	60	130	50
11. Winona Road				30	10	100	90	10	10	130	110	500	500
12. Smiths Creek				28,000	26,000			90	30				
Daily Precipitation	0→6:00 0.4			18.30 32mm 1.5mm		Trace				Trace			
Average Wind Speed and Direction	12.9 W	13.2 SW		18.5 SW		13.7 W		9.3 NW		20.7 NW		15.5 NNE	
Maximum Wind Speed and Direction	26.0 W	28.0 NE		37.0 SW		28.0 W		15.0 ENE		46.0 W		24.0 NNE	

HAMILTON REGIONAL HEALTH UNIT BACTERIOLOGICAL DATA 1979

WEEK OF: Aug 12 – 18

STATION	12	13 TC	13 FC	14 TC	14 FC	15 TC	15 FC	16 TC	16 FC	17 TC	17 FC	18 TC	18 FC
1. Ship Canal		70	<10	10	<10	50	40	40	20	<10	<10		
2. Killarney Avenue		60	20	10	10	30	<10	120	10	<10	<10		
3. Concession Stand		80	70	30	30	30	10	60	30	110	90		
4. Marine Dock		440	100	30	10	500	180	170	90	10	10		
5. W. Confederation Park		90	90	20	20	280	190	30	30	20	20		
5c. Change House		80	80	60	40	110	70	40	40				
5d. E. Confederation Park		120	100	60	60	30	10	70	40	20	20		
6. Grays Road		140	40	30	30	80	30	20	20	10	10		
7. Greens Road		120	120	20	20	80	60	50	20	20	20		
8. Cherry Beach		150	40	100	30	70	30	50	50	60	10		
9. Fruitland Road		20	10	120	50	80	50	110	110	40	10		
10. McNeilly Road		700	600	40	10	70	30	50	50	30	<10		
11. Winona Road		3700	2900	110	20	80	40	110	60	<10	<10		
12. Smiths Creek				80	10								
Daily Precipitation		19.00 → 24.00								21:00 → 24:00		6.50 → 12:00	
		2.6 mm				0.4 mm				2.0 mm		0.8 mm	
Average Wind Speed and Direction	13.9 SW-1	17.3 SW		25.1 W		16.4 NW		9.0 WNW		9.4 WNW		11.7 SW-1	
Maximum Wind Speed and Direction	24.0 ENE	37.0 WSW		44.0 WNW		24.0 WNW		15.0 W		19.0 SW		19.0 SSW	

HAMILTON REGIONAL HEALTH UNIT BACTERIOLOGICAL DATA 1979

WEEK OF: Aug 19-25

STATION	19	20 TC	20 FC	21 TC	21 FC	22 TC	22 FC	23 TC	23 FC	24 TC	24 FC	25 TC	25 FC
1. Ship Canal		140	10	<10	<10			70	10	10	10	<10	<10
2. Killarney Avenue		80	<10	<10	<10			100	40	10	10	10	10
3. Concession Stand		10	10	900	800			70	50	10	<10	10	10
4. Marine Dock		10	10	10	10			210	180	20	20	10	<10
5. W. Confederation Park		160	150	30	20			230	100	60	10	30	20
5c. Change House		50	40	80	80			330	100	90	40	90	10
5d. E. Confederation Park		30	30	<10	<10			220	100	20	10	30	<10
6. Grays Road		<10	<10	<10	<10			30	20			40	10
7. Greens Road		100	70	<10	<10			100	10	10	10	50	10
8. Cherry Beach		<10	<10	<10	<10			50	10	<10	<10	30	30
9. Fruitland Road		<10	<10	10	<10			10	<10	10	<10	70	60
10. McNeilly Road		<10	<10	10	10			80	10	10	10	2,500	2000
11. Winona Road		10	10	10	<10			50	50	<10	<10	60	10
12. Smiths Creek		400	400							<10	<10		
Daily Precipitation								3.00 → 8.30 4.6mm		Trace			
Average Wind Speed and Direction	6.4 NE	7.3 SW		9.7 NE		14.7 NE		13.8 SSW		17.7 SSW		16.3 WSW	
Maximum Wind Speed and Direction	15.0 N	11.0 ENE		19.0 ENE		24.0 ENE		24.0 SSW		24.0 SW		30.6 WSW	

HAMILTON REGIONAL HEALTH UNIT BACTERIOLOGICAL DATA 1979

WEEK OF: Aug 26 - Sept 1

		26		27		28		29		30		31		1	
STATION		TC	FC	TC	FC	TC	FC	TC	FC	TC	FC	TC	FC	TC	FC
1. Ship Canal		70	70	<10	<10	40	<10	20	<10	10	<10	700	<10		
2. Killarney Avenue		40	20	<10	<10	80	30	<10	<10	<10	<10	150	0.6		
3. Concession Stand		50	10	10	10	10	<10	10	10	10	10	90	<10		
4. Marine Dock		110	20	30	<10	20	<10	10	10	60	40	200	200		
5. W. Confederation Park		130	20	<10	<10	210	60	10	<10	40	40	400	100		
5c. Change House		50	50	20	<10	60	30	20	20	<10	<10	60	0.6		
5d. E. Confederation Park		300	50	<10	<10	220	20	10	<10	<10	<10	300	50		
6. Grays Road		650	600	<10	<10	40	30	20	20	40	20	200	100		
7. Greens Road		130	<10	10	<10	60	20	30	30	10	<10	800	20		
8. Cherry Beach		300	200	30	30	10	<10	10	10	40	40	200	10		
9. Fruitland Road		160	<10	20	20	50	10	30	30	20	20	120	20		
10. McNeilly Road		70	30	70	<10	1000	400	40	40	30	30	100	20		
11. Winona Road		20	<10	40	<10	1100	400	20	20	20	10	500	300		
12. Smiths Creek		2400	2400	3400	3400							0.6	0.6		
Daily Precipitation	19 to 24	0:00 → 6:45		5:45 → 22:00		11:30 → 18:20									
	12.4	2.0 mm		10.6 mm		1.2 mm									
Average Wind Speed and Direction	8.5 NE	7.5 SSW		8.6 ENE		15.0 SW		17.7 WSW		6.2 NNW					
Maximum Wind Speed and Direction	15.0 NE	19.0 SSW		13.0 NE		37.0 SW		30.0 WSW		19.0 NE					

HAMILTON REGIONAL HEALTH UNIT BACTERIOLOGICAL DATA 1979

WEEK OF: Sept 2 - 8

STATION	3 TC	3 FC	4 TC	4 FC	5 TC	5 FC	6 TC	6 FC	7 TC	7 FC	8 TC	8 FC
1. Ship Canal			70	20	160	60	10	<10	50	20		
2. Killarney Avenue			120	100	250	50	10	<10	40	30		
3. Concession Stand			50	20	170	60	50	20	70	<10		
4. Marine Dock			160	30	330	140	120	90	130	110		
5. W. Confederation Park			350	100	1000	100	190	120	120	40		
5c. Change House			140	40	170	50	60	30	350	30		
5d. E. Confederation Park			130	30	130	30	70	10	110	40		
6. Grays Road			60	<10	30	10	<10	<10	160	80		
7. Greens Road			110	70	200	60	20	10	40	10		
8. Cherry Beach			900	500	50	10	10	<10	<10	<10		
9. Fruitland Road			160	10	40	<10	50	20	30	20		
10. McNeilly Road			160	50	400	110	3,000	1,800	2500	2300		
11. Winona Road			340	40	100	20	<10	<10	900	400		
12. Smiths Creek							8,000	6,000				
Daily Precipitation												
Average Wind Speed and Direction												
Maximum Wind Speed and Direction												

Appendix 3

Climatological Data (June, July, August, 1979)

Fisheries and Environment Canada / Pêches et Environnement Canada
Atmospheric Environment / Environnement atmosphérique

MONTHLY METEOROLOGICAL SUMMARY
SOMMAIRE MÉTÉOROLOGIQUE MENSUEL

MONTH/MOIS JULY/JUILLET 19 79

AT/À HAMILTON AIRPORT ONTARIO

LAT 43° 10 'N LONG: 79° 56 'W ELEVATION: ALTITUDE: 237 METRES (ASL) MÈTRES (NMM) STANDARD TIME USED: HEURE NORMALE UTILISÉE: Eastern / de l'Est

DATE	TEMPERATURE TEMPÉRATURE			DEGREE-DAYS DEGRÉS-JOURS		REL. HUMIDITY HUMIDITÉ REL.		THUNDERSTORM ORAGE	PRECIPITATION PRÉCIPITATIONS			SNOW ON GROUND NEIGE AU SOL	WIND VENT			BRIGHT SUNSHINE INSOLATION EFFECTIVE
	MAXIMUM MAXIMALE	MINIMUM MINIMALE	MEAN MOYENNE	HEATING DE CHAUFFE	GROWING DE CROISSANCE	MAXIMUM MAXIMALE	MINIMUM MINIMALE		RAINFALL PLUIE (HAUTEUR)	SNOWFALL NEIGE (HAUTEUR)	TOTAL PRECIP. PRÉCIP. TOTALE		AVERAGE SPEED VITESSE MOYENNE	PREVAILING DIRECTION DIRECTION DOMINANTE	MAXIMUM SPEED AND DIRECTION VITESSE MAXIMALE ET DIRECTION	
	°C	°C	°C	BASE 18.0°C	BASE 5.0°C	%	%		mm	cm	mm	cm	km/h		km/h	** HOURS HEURES
1	18.1	15.5	15.9	1.1	11.9				3.2		3.2		15.7	S	S 26*	1.0
2	20.2	13.8	17.0	1.0	12.0				0.9		0.9		17.5	WNW	N W 30	5.0
3	23.5	9.7	16.6	1.4	11.6								16.9	W	W 26	14.2
4	21.5	10.0	15.8	2.2	10.8								12.3	NNW	NNW 28	13.6
5	20.8	8.0	14.4	3.6	9.4								18.0	svrl	NNW 30	13.4
6	24.0	8.7	16.4	1.6	11.4								13.8	W	WNW 19*	14.7
7	25.6	10.3	18.0		13.0								8.1	svrl	SW 15	14.2
8	26.7	13.9	20.3		15.3								8.5	svrl	S 15	13.7
9	25.5	16.1	20.8		15.8				1.2		1.2		7.5	NE	SSW 17	3.9
10	24.5	17.8	21.2		16.2				5.2		5.2		13.7	SSE	S 26*	3.9
11	27.5	15.7	21.6		16.6				0.2		0.2		11.0	WSW	S 22	7.0
12	30.1	18.6	24.4		19.4								9.1	W	SSW 17	10.5
13	30.1	17.6	23.9		18.9								9.0	NE	NE 19	13.1
14	30.0	20.9	25.5		20.5								9.2	SSW	SW 15	8.4
15	31.0	19.2	25.1		20.1								11.3	WNW	W 26	9.8
16	31.0	17.5	24.3		19.3								9.9	WNW	NNW 24	13.1
17	23.0	16.7	19.9		14.9								14.6	svrl	NE 26	6.1
18	26.0	13.0	19.5		14.5								8.3	NW	NNW 15	11.2
19	27.2	11.2	19.2		14.2								9.5	W	S 19	13.9
20	29.9	13.7	21.3		16.3								8.4	SW	SW 11*	13.9
21	29.1	13.3	21.2		16.2								8.4	SSW	SSW 17*	13.5
22	29.9	15.2	22.6		17.6								11.5	SSW	WSW 20	13.0
23	30.5	16.5	23.5		18.5								9.3	SSW	SSW 17	10.1
24	30.2	19.2	24.7		19.7								17.1	SW	SW 30*	11.1
25	29.7	21.3	25.5		20.5				20.9		20.9		20.8	SSW	SW 37	4.0
26	22.5	17.5	20.0		15.0								18.8	WNW	WNW 30	2.5
27	24.6	15.6	20.1		15.1								5.5	svrl	NW 11	7.6
28	23.7	15.9	19.8		14.8				2.2		2.2		12.9	SSW	SW 30	2.9
29	28.0	12.8	20.4		15.4								6.6	NW	ENE 11*	13.7
30	27.9	15.0	21.5		16.5				3.2		3.2		11.2	SW	S 20	11.1
31	26.0	21.2	23.6		18.6			1	8.0		8.0		15.3	SSW	SSW 22	2.1
MEAN MOYENNE	26.4	15.2	20.8	TOTAL 11.0	TOTAL 469.9			TOTAL 1	TOTAL 45.0	TOTAL 0.0	TOTAL 45.0		11.9	PREVAILING SSW DOMINANTE	MAXIMUM SW 37	TOTAL 296.2
NORMAL NORMALE	26.5	14.6	20.6	10.1	472.6				71.9	0.0	71.9					281.2

DEGREE-DAY SUMMARY – SOMMAIRE DE DEGRÉS-JOURS

BELOW 18°C AU-DESSOUS DE 18°C	THIS YEAR ANNÉE EN COURS	PREVIOUS YEAR ANNÉE PRÉCÉDENTE	NORMAL NORMALE	ABOVE 5°C AU-DESSUS DE 5°C	THIS YEAR ANNÉE EN COURS	PREVIOUS YEAR ANNÉE PRÉCÉDENTE	NORMAL NORMALE
TOTAL FOR MONTH TOTAL DU MOIS	11.0	15.3	10.1	TOTAL FOR MONTH TOTAL DU MOIS	469.9	466.6	472.6
ACCUMULATED SINCE JULY 1 ACCUMULÉE DEPUIS LE 1er JUILLET	11.0	15.3	10.1	ACCUMULATED SINCE APRIL 1 ACCUMULÉE DEPUIS LE 1er AVRIL	1137.2	1136.3	1176.6

DAYS WITH TOTAL PRECIPITATION JOURS AVEC PRÉCIPITATIONS TOTALES. mm					DAYS WITH SNOWFALL: JOURS AVEC CHÛTE DE NEIGE: cm				
0.2 OR MORE – OU PLUS	1.0 OR MORE – OU PLUS	2.0 OR MORE – OU PLUS	10.0 OR MORE – OU PLUS	50.0 OR MORE – OU PLUS	0.2 OR MORE – OU PLUS	1.0 OR MORE – OU PLUS	2.0 OR MORE – OU PLUS	10.0 OR MORE – OU PLUS	50.0 OR MORE – OU PLUS
9	7	6	1	0	0	0	0	0	0

UDC 551.506.1 (713.53) * Indicates more than one occurrence.
** Sunshine recorder at Royal Botanical Gardens. Tr= trace

Subscription Price: $1.00 monthly $10.00 per calendar year (January to December)
Prix d'abonnement: mensuel $1.00; annuel $10.00 (janvier à décembre)

Fisheries and Environment Canada / Pêches et Environnement Canada
Atmospheric Environment / Environnement atmosphérique

MONTHLY METEOROLOGICAL SUMMARY
SOMMAIRE MÉTÉOROLOGIQUE MENSUEL

MONTH/MOIS AUGUST/AOUT 19 79

AT/À STONEY CREEK

LAT: 43 ° 10 'N LONG: 79 ° 56 'W ELEVATION/ALTITUDE: 237 METRES (ASL) / MÈTRES (NMM) STANDARD TIME USED/HEURE NORMALE UTILISÉE: Eastern / de l'Est

DATE	TEMPERATURE MAXIMUM °C	TEMPERATURE MINIMUM °C	TEMPERATURE MEAN °C	DEGREE-DAYS HEATING BASE 18.0°C	DEGREE-DAYS GROWING BASE 5.0°C	REL. HUMIDITY MAXIMUM %	REL. HUMIDITY MINIMUM %	THUNDERSTORM	PRECIPITATION RAINFALL mm	PRECIPITATION SNOWFALL cm	PRECIPITATION TOTAL mm	SNOW ON GROUND cm	WIND AVERAGE SPEED km/h	WIND PREVAILING DIRECTION	WIND MAXIMUM SPEED AND DIRECTION km/h	BRIGHT SUNSHINE ** HOURS
1	21.5	19.6	20.6		15.6				3.0		3.0		11.9	ENE	NE 19*	0.0
2	23.4	16.6	20.0		15.0			1	23.2		23.2		17.8	W	W 37	6.2
3	26.5	15.0	20.8		15.8				Tr		Tr		13.7	SW	WSW 33	10.4
4	29.0	17.4	23.2		18.2								11.4	SSW	WSW 20*	12.3
5	28.1	19.7	23.9		18.9				0.4		0.4		12.9	W	W 26	11.8
6	23.6	15.5	19.6		14.6								13.2	svrl	NE 28	12.0
7	28.0	10.9	19.5		14.5			1	1.5		1.5		18.5	SW	SW 37	4.0
8	25.6	15.0	20.3		15.3				Tr		Tr		13.7	W	W 28	1.8
9	23.7	10.8	17.3	0.7	12.3								9.3	NW	ENE 15	10.0
10	25.0	16.2	20.6		15.6				Tr		Tr		20.7	NW	W 46*	6.6
11	19.5	14.1	16.8	1.2	11.8								15.5	NNE	NNE 24	2.8
12	20.6	11.0	15.8	2.2	10.8								13.9	svrl	ENE 24	12.8
13	22.6	9.2	15.9	2.1	10.9				2.6		2.6		17.3	SW	WSW 37	7.7
14	19.8	9.6	14.7	3.3	9.7								25.1	W	WNW 44	8.6
15	17.0	9.6	13.3	4.7	8.3				0.4		0.4		16.4	NW	WNW 24*	4.6
16	21.6	7.2	14.4	3.6	9.4								9.0	WNW	W 15	10.7
17	19.5	8.9	14.2	3.8	9.2				2.0		2.0		9.4	WNW	SW 19	2.3
18	19.9	12.9	16.4	1.6	11.4				0.8		0.8		11.7	svrl	SSW 19	0.0
19	24.8	14.6	19.7		14.7								6.4	NE	N 15	11.1
20	25.3	13.5	19.4		14.4								7.3	svrl	ENE 11*	8.6
21	26.7	14.2	20.5		15.5								9.7	NE	ENE 19	12.5
22	24.1	15.2	19.7		14.7								14.7	NE	ENE 24	10.6
23	24.7	18.4	21.6		16.6			1	4.6		4.6		13.8	SSW	SSW 24	0.2
24	25.0	20.2	22.6		17.6				Tr		Tr		17.7	SSW	SW 24*	4.4
25	23.0	12.8	17.9	0.1	12.9								16.3	WSW	WSW 30	7.2
26	21.5	14.7	18.1		13.1				12.4		12.4		8.5	NE	NE 15	3.6
27	22.8	14.2	18.5		13.5				2.0		2.0		7.5	SSW	SSW 19	9.0
28	22.7	16.2	19.5		14.5			1	10.6		10.6		8.6	ENE	NE 13*	1.8
29	24.0	18.2	21.1		16.1				1.2		1.2		15.0	SW	SW 37	2.3
30	27.6	16.0	21.8		16.8								17.7	WSW	WSW 30	
31	24.5	11.0	17.8	0.2	12.8								6.2	NNW	NE 19	12.7
MEAN MOYENNE	23.6	14.1	18.9	TOTAL 23.5	TOTAL 430.5			TOTAL 4	TOTAL 64.7	TOTAL 0.0	TOTAL 64.7		13.3	PREVAILING W DOMINANTE	MAXIMUM W 46*	TOTAL 221.1
NORMAL NORMALE	26.0	13.5	19.8	12.6	470.9				71.1	0.0	71.1					262.6

DEGREE-DAY SUMMARY – SOMMAIRE DE DEGRÉS-JOURS

BELOW 18°C / AU-DESSOUS DE 18°C	THIS YEAR / ANNÉE EN COURS	PREVIOUS YEAR / ANNÉE PRÉCÉDENTE	NORMAL / NORMALE	ABOVE 5°C / AU-DESSUS DE 5°C	THIS YEAR / ANNÉE EN COURS	PREVIOUS YEAR / ANNÉE PRÉCÉDENTE	NORMAL / NORMALE
TOTAL FOR MONTH / TOTAL DU MOIS	2.5	2.3	12.6	TOTAL FOR MONTH / TOTAL DU MOIS	430.5	474.1	470.9
ACCUMULATED SINCE JULY 1 / ACCUMULÉE DEPUIS LE 1er JUILLET	34.5	17.6	22.7	ACCUMULATED SINCE APRIL 1 / ACCUMULÉE DEPUIS LE 1er AVRIL	1567.7	1610.4	1647.5

DAYS WITH TOTAL PRECIPITATION: JOURS AVEC PRÉCIPITATIONS TOTALES: mm

0.2 OR MORE / OU PLUS	1.0 OR MORE / OU PLUS	2.0 OR MORE / OU PLUS	10.0 OR MORE / OU PLUS	50.0 OR MORE / OU PLUS
13	10	8	3	0

DAYS WITH SNOWFALL: JOURS AVEC CHÛTE DE NEIGE: cm

0.2 OR MORE / OU PLUS	1.0 OR MORE / OU PLUS	2.0 OR MORE / OU PLUS	10.0 OR MORE / OU PLUS	50.0 OR MORE / OU PLUS
0	0	0	0	0

UDC 551.506.1 (713.53)

* Indicates more than one occurrence.

** Sunshine recorder at Royal Botanical Gardens. Tr = trace.

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Fisheries and Environment Canada / Pêches et Environnement Canada

Atmospheric Environment / Environnement atmosphérique

MONTHLY METEOROLOGICAL SUMMARY
SOMMAIRE MÉTÉOROLOGIQUE MENSUEL

MONTH/MOIS SEPTEMBER/SEPTEMBRE 1979

AT/À HAMILTON AIRPORT ONTARIO

LAT: 43 ° 10N LONG: 79° 56 W ELEVATION: ALTITUDE: 237 METRES (ASL) MÈTRES (NMM) STANDARD TIME USED: HEURE NORMALE UTILISÉE Eastern de l'Est

DATE	TEMPERATURE TEMPÉRATURE			DEGREE-DAYS DEGRÉS-JOURS		REL. HUMIDITY HUMIDITÉ REL.		THUNDERSTORM ORAGE	PRECIPITATION PRÉCIPITATIONS			SNOW ON GROUND NEIGE AU SOL	WIND VENT			BRIGHT SUNSHINE INSOLATION EFFECTIVE
	MAXIMUM MAXIMALE °C	MINIMUM MINIMALE °C	MEAN MOYENNE °C	HEATING DE CHAUFFE BASE 18.0°C	GROWING DE CROISSANCE BASE 5.0°C	MAXIMUM MAXIMALE %	MINIMUM MINIMALE %		RAINFALL PLUIE (HAUTEUR) mm	SNOWFALL NEIGE (HAUTEUR) cm	TOTAL PRECIP. PRÉCIP. TOTALE mm	cm	AVERAGE SPEED VITESSE MOYENNE km/h	PREVAILING DIRECTION DIRECTION DOMINANTE	MAXIMUM SPEED AND DIRECTION VITESSE MAXIMALE ET DIRECTION km/h	** HOURS HEURES
1	30.1	13.8	22.0		17.0								10.5	S	S 19*	8.9
2	24.1	20.2	22.2		17.2				0.4		0.4		20.9	SW	SW 35	0.6
3	25.7	16.5	21.1		16.1								13.2	W	W 17	9.3
4	23.0	13.3	18.2		13.2								10.8	NE	NE 13	9.4
5	24.8	14.2	19.5		14.5								12.9	NE	NE 19*	8.1
6	28.2	15.0	21.6		16.6								16.2	WNW	W 32	7.4
7	18.0	11.1	14.6	3.4	9.6				3.0		3.0		12.2	NNW	NNW 22	1.2
8	15.3	7.5	11.4	6.6	6.4								12.1	N	NNE 22*	10.5
9	18.6	5.7	12.2	5.8	7.2								10.0	SSW	SSW 20	9.0
10	23.0	9.5	16.3	1.7	11.3			1	1.4		1.4		20.5	SW	SW 44	3.6
11	18.2	7.6	12.9	5.1	7.9								12.3	NE	NE 26	11.0
12	23.3	9.5	16.4	1.6	11.4								11.6	NE	NE 19*	10.6
13	25.1	15.2	20.2		15.2				8.4		8.4		18.0	S	SSW 33	2.3
14	19.0	9.0	14.0	4.0	9.0				38.8		38.8		17.3	WNW	NW 35	3.6
15	17.6	6.2	11.9	6.1	6.9								13.8	W	W 26	10.6
16	21.6	8.4	15.0	3.0	10.0								11.8	SW	WSW 24*	8.8
17	23.0	9.5	16.3	1.7	11.3								16.9	WSW	W 30	10.3
18	24.2	13.5	18.9		13.9			1	4.4		4.4		21.7	SW	WSW 32	7.6
19	15.0	3.6	9.3	8.7	4.3								15.8	NNW	NNW 32	10.4
20	19.3	2.1	10.7	7.3	5.7								16.6	SW	SW 35	10.9
21	20.0	9.2	14.6	3.4	9.6								14.3	N	SW 24	0.0
22	15.6	6.6	11.1	6.9	6.1								17.0	N	NE 30	7.2
23	15.0	4.7	9.9	8.1	4.9								15.8	ENE	ENE 22*	9.8
24	19.0	4.7	11.9	6.1	6.9								9.6	S	S 19	9.0
25	22.9	8.2	15.6	2.4	10.6								14.2	SW	WSW 30	6.3
26	23.0	8.5	15.8	2.2	10.8								8.0	W	W 11*	9.9
27	24.0	8.2	16.1	1.9	11.1								10.4	svrl	SSW 19*	9.3
28	17.9	13.5	15.7	2.3	10.7				3.0		3.0		8.8	svrl	SSW 19	0.0
29	21.4	11.6	16.5	1.5	11.5								3.8	E	NE 11*	3.2
30	22.9	10.5	16.7	1.3	11.7								9.4	SSW	SSW 20	5.8
MEAN MOYENNE	21.3	9.9	15.6	TOTAL 91.1	TOTAL 318.6	n/a	n/a	TOTAL 2	TOTAL 59.4	TOTAL 0.0	TOTAL 59.4		13.5	PREVAILING DOMINANTE SW	MAXIMUM SW 44	TOTAL 214.6
NORMAL NORMALE	21.7	10.2	15.9	87.1	336.4				73.4	0.0	73.4					173.5

DEGREE-DAY SUMMARY – SOMMAIRE DE DEGRÉS-JOURS

BELOW 18°C AU-DESSOUS DE 18°C	THIS YEAR ANNÉE EN COURS	PREVIOUS YEAR ANNÉE PRÉCÉDENTE	NORMAL NORMALE	ABOVE 5°C AU-DESSUS DE 5°C	THIS YEAR ANNÉE EN COURS	PREVIOUS YEAR ANNÉE PRÉCÉDENTE	NORMAL NORMALE
TOTAL FOR MONTH TOTAL DU MOIS	91.1	90.8	87.1	TOTAL FOR MONTH TOTAL DU MOIS	318.6	317.3	336.4
ACCUMULATED SINCE JULY 1 ACCUMULÉE DEPUIS LE 1er JUILLET	125.6	108.4	109.8	ACCUMULATED SINCE APRIL 1 ACCUMULÉE DEPUIS LE 1er AVRIL	1886.3	1927.7	1983.9

DAYS WITH TOTAL PRECIPITATION: JOURS AVEC PRÉCIPITATIONS TOTALES: mm					DAYS WITH SNOWFALL: JOURS AVEC CHÛTE DE NEIGE: cm				
0.2 OR MORE – OU PLUS	1.0 OR MORE – OU PLUS	2.0 OR MORE – OU PLUS	10.0 OR MORE – OU PLUS	50.0 OR MORE – OU PLUS	0.2 OR MORE – OU PLUS	1.0 OR MORE – OU PLUS	2.0 OR MORE – OU PLUS	10.0 OR MORE – OU PLUS	50.0 OR MORE – OU PLUS
7	6	5	1	0	0	0	0	0	0

UDC 551.506.1 (713.53) * Indicates more than one occurrence.

** Sunshine recorder at Royal Botanical Gardens. Tr =trace.

Subscription Price: $1.00 monthly; $10.00 per calendar year (January to December)
Prix d'abonnement: mensuel $1.00; annuel $10.00 (janvier à décembre)

Monthly Weather Summary
Hamilton Ontario

For the month of JUNE 1979 at the ROYAL BOTANICAL GARDENS
Headquarters - Plains Road West, BURLINGTON, ONTARIO.

Date	Temperature			Degree Days		Precipitation				Wind km/h			Sunshine	
	Maximum °C	Minimum °C	Mean °C	Heating Below 18°C	Growing Over 5°C	Rain mm	Snow cm	Total Precipitation mm	Rainfall in 10 min. mm	Average Speed	Prevailing Direction	Maximum speed and direction	Actual hrs	Total possible hr
1	20.2	12.0	16.2	1.8	11.2					9.5	NE	SE19	13.3	15.
2	26.2	14.6	20.4		15.4					7.5	NW	NW13	10.0	15.
3	27.6	12.9	20.3		15.3					11.7	SW	SW21	12.8	15.
4	30.4	13.9	22.2		17.2	1.6		1.6	1.4	11.5	SW	SW19	12.1	15.
5	23.0	16.2	19.6		14.6	1.2		1.2	0.6	10.0	NW	NW19	7.4	15.
6	17.4	11.1	14.3	3.7	9.3					13.4	NE	E19	11.5	15.
7	20.1	11.5	15.8	2.2	10.8	3.6		3.6	1.3	6.5	NE	NE13	7.2	15.
8	27.7	16.0	21.9		16.9					9.1	SW	SW18	5.5	15.
9	25.3	18.2	21.8		16.8					7.3	NE	E11	7.6	15.
10	31.9	17.4	24.7		19.7	1.0		1.0	1.0	14.5	SW	SW27	6.9	15.
11	18.9	12.5	15.7	2.3	10.7					18.5	NW	NW27	7.1	15.
12	19.4	6.8	13.1	4.9	8.1					14.5	NW	NW21	8.8	15.
13	24.4	8.3	16.4	1.6	11.4					11.1	NW	NW18	13.0	15.
14	27.7	9.0	18.4		13.4					11.5	SW	SW18	12.8	15.
15	32.7	19.5	26.1		21.1					16.0	SW	SW24	12.4	15.
16	33.7	19.7	26.7		21.7					12.9	SW	SW21	11.9	15.
17	32.1	17.6	24.9		19.9					13.7	SW	SW24	11.9	15.
18	22.0	13.4	17.7	0.3	12.7					9.0	NE	NE16	7.7	15.
19	23.7	10.6	17.2	0.8	12.2					9.1	NE	NE14	14.3	15.
20	23.5	11.0	17.8	0.2	12.8					9.2	NE	NE18	14.5	15.
21	30.2	16.0	23.1		18.1	TR		TR		12.6	SW	SW18	4.9	15.
22	26.0	15.0	20.5		15.5					15.9	NW	NW34	4.1	15.
23	14.1	9.7	11.9	6.1	6.9					16.9	NW	NW21	0.2	15.
24	22.4	7.1	14.8	3.2	9.8					10.7	NW	N 16	12.9	15.
25	21.5	9.1	15.3	2.7	10.3					8.6	NE	N 14	14.4	15.
26	26.8	7.2	17.0	1.0	12.0					8.7	SW	SW18	14.1	15.
27	27.3	15.9	21.6		16.6	17.4		17.4	3.4	12.7	SW	SW21	4.5	15.
28	23.6	15.4	19.5		14.5	1.8		1.8	1.0	7.3	NE	NW16	9.8	15.
29	19.5	13.0	16.3	1.7	11.3	4.2		4.2	1.0	7.0	NE	SE13	0.0	15.
30	19.4	14.0	16.7	1.3	11.7	7.6		7.6	3.4	7.3	NE	NE13	0.0	15.
Total	738.7	394.6	-	33.8	417.8	38.4		38.4		-	SW	-	273.6	458.
Mean	24.6	13.2	18.9	-	-	-	-	-	-	11.1	-	-	-	-
Normal	24.4	13.1	18.8	37.4	413.3	65.0	NIL	65.0		11.4	-	-	256.3	

Observations are taken at 7:00 a.m. and 7:00 p.m. E.S.T. under contract to Canada Environment.
Normals for temperature, precipitation and means are based on the period 1941 to 1970.

Latitude N. 43° 17'
Longitude W. 79° 53'
Elevation 352 ft.

Monthly Weather Summary
Hamilton Ontario

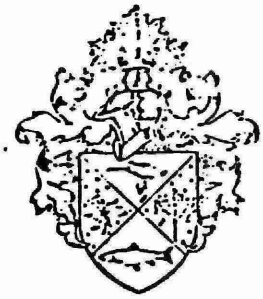
For the month of JULY 19 79 at the ROYAL BOTANICAL GARDENS
Headquarters - Plains Road West, BURLINGTON, ONTARIO.

Date	Temperature			Degree Days		Precipitation				Wind km/h			Sunshine	
	Maximum °C	Minimum °C	Mean °C	Heating Below 18°C	Growing Over 5°C	Rain mm	Snow cm	Total Precipitation mm	Rainfall in 10 min. mm	Average Speed	Prevailing Direction	Maximum speed and direction	Actual . hrs	Total, possible hrs
1	20.8	16.5	18.7		13.7	1.2		1.2	0.4	8.5	SW	S16	1.0	15.3
2	23.4	17.2	20.3		15.3					12.7	NW	NW22	5.0	15.3
3	25.3	12.2	18.8		13.8					11.9	NW	NW16	14.2	15.3
4	23.6	11.5	17.5	0.5	12.6					9.8	NW	NW22	13.6	15.2
5	22.6	8.9	15.8	2.2	10.8					12.9	NW	N19	13.4	15.2
6	26.5	10.9	18.7		13.7					9.8	NW	NW16	14.7	15.2
7	28.4	11.0	19.7		14.7					8.1	SW	SW13	14.2	15.2
8	30.1	14.5	22.3		17.3					6.1	SW	SW10	13.7	15.2
9	26.0	15.1	20.5		15.5	0.8		0.8	0.6	5.8	NE	NE13	3.9	15.2
10	27.4	18.8	23.1		18.1	2.2		2.2	1.6	8.7	SW	SW16	3.9	15.2
11	28.5	17.1	22.8		17.8					6.7	SW	SW16	7.0	15.1
12	32.4	20.1	26.3		21.3					7.0	SW	W10	10.5	15.1
13	29.4	17.8	23.6		18.6	TR		TR		6.9	NE	E14	13.1	15.1
14	32.9	21.0	26.9		21.9	TR		TR		5.2	SW	SW8	8.4	15.1
15	33.6	22.9	28.3		23.3					8.1	SW	NW14	9.8	15.0
16	33.0	20.1	26.6		21.6					7.9	NE	NE16	13.1	15.0
17	24.4	17.5	21.0		16.0					10.7	NE	NE18	6.1	15.0
18	26.3	15.1	20.7		15.7					8.0	NE	SE14	11.2	15.0
19	30.6	12.5	21.6		16.6					7.1	NW	W10	13.9	15.0
20	30.4	16.1	23.3		18.3					8.5	SW	NE11	13.9	14.9
21	31.8	16.1	24.0		19.0					9.0	SW	E18	13.5	14.9
22	33.1	18.1	25.6		20.6					9.2	SW	SW14	13.0	14.9
23	29.0	18.6	23.8		18.8					8.5	NE	NE14	10.1	14.8
24	33.5	21.0	27.3		22.3	TR		TR		11.6	SW	SW21	11.1	14.8
25	32.1	21.4	26.8		21.8	15.2		15.2		12.4	SW	SW21	4.0	14.8
26	26.2	20.2	23.2		18.2					13.2	NW	NW21	2.5	14.7
27	26.5	17.4	22.0		17.0	0.2		0.2	3.4	4.7	SW	SW8	7.6	14.7
28	27.2	17.9	22.6		17.6	0.6		0.6	0.6	9.1	SW	SW19	2.9	14.7
29	27.3	15.5	21.4		16.4					8.5	NE	NE13	13.7	14.6
30	28.5	14.9	21.7		16.7	8.2		8.2	3.4	6.6	NE	SW11	11.1	14.6
31	29.6	20.2	24.9		19.9	4.0		4.0	1.2	8.3	SW	SW16	2.1	14.6
Total	888.4	518.1	-	2.7	544.9	32.4		32.4	-	-	SW	-	296.2	464.7
Ave	28.4	16.7	22.6	-	-	-		-	-	8.8	-	-	-	-
Norm	27.2	15.9	21.6	6.4	513.6	71.6	nil	71.6	-	10.6	-	-	287.1	-

Observations are taken at 7:00 a.m. and 7:00 p.m. E.S.T. under contract to Canada Environment.
Normals for temperature, precipitation and means are based on the period 1941 to 1970.

Latitude N. 43° 17'
Longitude W. 79° 53'
Elevation 352 ft.

Monthly Weather Summary
Hamilton Ontario



For the month of August 1979 at the ROYAL BOTANICAL GARDENS
Headquarters - Plains Road West, BURLINGTON, ONTARIO.

Date	Temperature			Degree Days		Precipitation				Wind km			Sunshine	
	Maximum °C	Minimum °C	Mean °C	Heating Below 18°C	Growing Over 5°C	Rain mm	Snow cm	Total Precipitation mm	Rainfall in 10 min. mm	Average Speed	Prevailing Direction	Maximum speed and direction	Actual hrs	Total possible hrs
1	24.2	21.0	22.6		17.6	23.2		23.2	7.0	8.3	NE	NE13	0.0	14.5
2	27.5	20.5	24.0		19.0					12.9	SW	SW26	6.2	14.5
3	30.1	18.5	24.3		19.3					9.8	SW	SW21	10.4	14.4
4	31.8	19.1	25.5		20.5					8.9	SW	SW14	12.3	14.4
5	31.1	21.0	26.1		21.1	2.8		2.8	2.8	9.9	SW	SW16	11.8	14.4
6	23.8	19.6	21.7		16.7					9.7	NE	NE18	12.0	14.3
	29.3	12.8	21.1		16.1	0.4		0.4	0.4	11.3	SW	SW26	4.0	14.3
	27.8	16.4	22.1		17.1		..			10.4	SW	SW16	1.8	14.3
	21.1	12.8	17.0	1.0	12.0	4.6		4.6	4.2	9.2	NE	NE18	10.0	14.2
10	26.2	17.3	21.8		16.8	0.6		0.6	0.6	12.0	NW	NW27	6.6	14.2
11	19.2	15.6	17.4	0.6	12.4					9.9	NE	N14	2.8	14.1
12	19.9	12.2	16.1	1.9	11.1					9.8	NE	NE21	12.8	14.1
13	25.0	9.4	17.2	0.8	12.2	1.6		1.6	0.5	13.7	SW	SW26	7.7	14.0
14	21.2	14.0	17.6	0.4	12.6	TR		TR		18.7	NW	NW34	8.6	14.0
15	18.9	11.2	15.1	2.9	10.1					14.5	NW	NW22	4.6	14.0
16	20.3	8.7	14.5	3.5	9.5					7.9	NE	NE16	10.7	13.9
17	21.9	10.5	16.2	1.8	11.2	2.6		2.6	0.6	6.7	SW	SW11	2.3	13.9
18	21.3	13.9	17.6	0.4	12.6	0.2		0.2		4.1	SW	SW8	0.0	13.8
19	22.9	15.0	18.9		13.9					8.1	NE	NE14	11.1	13.8
20	24.6	12.9	19.0		14.0					7.6	NE	NE10	8.6	13.7
21	25.6	12.8	19.2		14.2					5.6	NE	E10	12.5	13.7
22	21.0	14.5	17.8	0.2	12.8	2.6		2.6	0.8	9.2	NE	E19	10.6	13.6
23	26.2	16.9	21.6		16.6	6.4		6.4	1.2	6.5	SW	SW13	0.2	13.6
24	27.1	21.4	24.3		19.3	0.4		0.4	0.2	11.1	SW	SW18	4.4	13.5
25	24.2	14.5	19.4		14.4					11.0	SW	SW16	7.2	13.5
26	20.0	14.5	17.3	0.7	12.3	11.2		11.2	1.4	6.8	NE	NE14	3.6	13.5
27	24.2	15.2	19.7		14.7	0.2		0.2	0.1	5.6	SW	Svr11	9.0	13.4
28	21.1	16.0	18.6		13.6	4.0		4.0	1.0	7.6	NE	NE14	1.8	13.4
29	26.2	15.6	22.4		17.4	1.8		1.8	0.8	9.3	SW	SW24	2.3	13.3
30	29.5	19.5	24.5		19.5					13.9	SW	W21	12.5	13.3
	26.6	13.1	19.9		14.9					8.1	NE	NE14	12.7	13.3
	759.8	479.4	-	14.2	465.5	62.6	0	62.6	-	-	SW	-	221.1	432.1
	24.5	15.5	20.0	-	-	-	-	-	-	9.6	-	-	-	-
Normal	26.2	15.2	20.7	10.9	486.5	85.9	0	85.9	-	10.1	-	-	262.0	-

Observations are taken at 8:00 a.m. and 7:00 p.m. E.S.T. under contract to Canada Environment.
Normals for temperature, precipitation and means are based on the period 1941 to 1970.

Latitude N. 43° 17'
Longitude W. 79° 53'
Elevation 352 ft.

CLIMATE SUMMARY FOR HAMILTON MUNICIPAL LAB JUNE 1979
ONTARIO REGION ID : 3570B
AES HEADQUARTERS ID : 6153290

DAY	TEMPERATURE MAX	MIN	MEAN	TOTAL RAIN	SNOW	PCP	T H	Z R	H A	SNOW GND
1	18.0	10.0	14.0							
2	25.0	14.5	19.8							
3	27.0	14.0	20.5							
4	29.0	16.0	22.5	.2		.2	X			
5	23.5	12.0	17.8	.8		.8				
6	15.0	11.5	13.3							
7	21.5	11.0	16.3	.6		.6				
8	27.5	14.5	21.0							
9	23.0	17.5	20.3							
10	31.5	16.5	24.0	.4		.4				
11	18.0	13.0	15.5							
12	18.0	9.0	13.5	T		T				
13	23.0	10.5	16.8							
14	26.0	11.5	18.8							
15	31.0	19.5	25.3							
16	31.0	21.5	26.3							
17	31.0	19.0	25.0							
18	21.0	13.5	17.3							
19	21.0	14.5	17.8							
20	23.0	13.0	18.0	T		T				
21	28.0	15.5	21.8	.3		.3				
22	25.0	15.0	20.0	T		T				
23	14.5	10.5	12.5							
24	19.5	10.0	14.8							
25	20.0	11.0	15.5							
26	25.0	9.5	17.3							
27	26.0	16.5	21.3	27.6		27.6				
28	22.0	15.5	18.8							
29	14.0	12.5	13.3	4.7		4.7				
30	17.5	13.0	15.3	7.3		7.3	X			M
TOTAL	695.5	411.5		41.9	0.0	41.9	2	0	0	
MEAN	23.2	13.7	18.5							

ONTHLY MAXIMUM TEMPERATURE WAS 31.5 ON DAY 10
ONTHLY MINIMUM TEMPERATURE WAS 9.0 ON DAY 12
IGHEST RAINFALL WAS 27.6 ON DAY 27

IST OF CODES USED IS AVAILABLE ON REQUEST

CLIMATE SUMMARY FOR HAMILTON MUNICIPAL LAB JULY 1979
ONTARIO REGION ID : 35708
AES HEADQUARTERS ID : 6153299

DAY	TEMPERATURE MAX	MIN	MEAN	TOTAL RAIN	SNOW	PCP	T H	Z R	H A	SNOW GND
1	20.5	14.0	17.3	1.0		1.0				
2	22.5	16.0	19.3							
3	25.5	14.0	19.8							
4	22.5	14.0	18.3							
5	21.0	12.0	16.5							
6	25.0	13.5	19.3							
7	27.5	13.5	20.5							
8	26.0	16.0	21.0							
9	22.0	16.0	19.0	.8		.8				
10	26.0	19.0	22.5	2.0		2.0				
11	28.0	18.0	23.0							
12	29.0	20.0	24.5							
13	28.0	21.0	24.5							
14	32.0	22.0	27.0							
15	33.0	22.5	27.8							
16	31.0	22.0	26.5							
17	23.0	18.5	20.8							
18	25.0	17.5	21.3							
19	27.5	16.0	21.8							
20	28.5	18.0	23.3							
21	29.0	17.0	23.0							
22	32.5	19.0	25.8							
23	29.0	20.5	21.8							
24	31.5	21.5	26.5	.2		.2				
25	31.0	23.5	27.3	8.6		8.6	X			
26	24.5	22.0	23.3							
27	24.0	18.5	21.3							
28	26.0	19.0	22.5	.5		.5				
29	27.0	17.0	22.0							
30	29.0	18.0	23.5	1.4		1.4				
31	28.5	21.5	25.0	3.7		3.7	X			M
TOTAL	835.5	561.0		21.2	0.0	21.2	2	0	0	
MEAN	27.0	18.1	22.5							

MONTHLY MAXIMUM TEMPERATURE WAS 33.0 ON DAY 15
MONTHLY MINIMUM TEMPERATURE WAS 12.0 ON DAY 5
HIGHEST RAINFALL WAS 8.6 ON DAY 25

LIST OF CODES USED IS AVAILABLE ON REQUEST

CLIMATE SUMMARY FOR HAMILTON MUNICIPAL LAB AUGUST 1979
ONTARIO REGION ID : 35708
LACS HEADQUARTERS ID : 6153290

DAY	TEMPERATURE MAX	MIN	MEAN	RAIN	TOTAL SNOW	TOF	T	SNOW ON GND
1	22.5	20.0	21.3	25.2		25.2		
2	26.0	20.0	23.0	T		T		
3	29.0	19.0	24.0					
4	31.5	20.5	26.0					
5	30.5	22.0	26.3	.6		.6		
6	25.0	19.5	22.3					
7	30.0	15.5	22.8	T		T		
8	28.0	18.5	23.3					
9	25.0	15.0	20.0	T		T		
10	27.0	17.0	22.0	T		T		
11	19.0	15.0	17.0					
12	19.5	13.0	16.3					
13	25.5	11.5	18.5	1.1		1.1		
14	21.5	15.0	18.3					
15	18.5	12.5	15.5					
16	21.5	11.0	16.3					
17	23.0	12.0	17.5	1.8		1.8		
18	21.0	14.5	17.8	T		T		
19	23.5	15.5	19.5					
20	23.0	15.0	19.0					
21	24.0	15.0	19.5					
22	20.5	16.5	18.5	9.0		9.0		
23	26.5	17.0	21.8	3.9		3.9		
24	27.0	22.0	24.5					
25	25.0	16.0	20.5					
26	20.0	16.0	18.0	13.2		13.2		
27	24.0	16.0	20.0	1.8		1.8		
28	21.0	17.5	19.3	4.4		4.4		
29	25.5	19.0	22.3	.8		.8		
30	30.0	20.5	25.3					
31	21.0	15.0	18.0					M
TOTAL	755.0	512.5		61.7	0.0	61.7	0 0 0	
MEAN	24.4	16.5	20.4					

MONTHLY MAXIMUM TEMPERATURE WAS 31.5 ON DAY 4
MONTHLY MINIMUM TEMPERATURE WAS 11.0 ON DAY 16
HIGHEST RAINFALL WAS 25.2 ON DAY 1

LIST OF CODES USED IS AVAILABLE ON REQUEST

Appendix 4

MOE Bacterial Data

(a) Sources and Inputs
(b) Lake Ontario Nearshore

TABLE 2.1 Bacterial Populations in Watercourses draining to Lake Ontario in the Study Area

Station #[1]	Fecal Coliform per 100 ml		Fecal Streptococci per 100 ml		Heterotrophic Bacteria per 1 ml		Pseudomonas aeruginosa per 100 ml		Candida albicans per litre	
	Dry[2]	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
2	85	132	78	272	325,000	840,000	3	17	2	7
4	13	14	26	108	116,000	264,000	3	4	0[3]	7
6	397	2,470	289	4,860	630,000	1,640,000			4[3]	20
7	27	159	240	1,660	178,000	316,000	6	11	2	3
8	103	1,000	159	2,310	352,000	1,230,000	7	98	2	6
9	54	843	271	2,810	115,000	938,000	3	36	2	6
11	116	1,240[3]	756	8,600[3]	112,000	2,150,000[3]	3	340[3]		
12b	486	423	828	2,250	1,040,000	1,400,000	4	8	2	7
12d	162	600	448	1,750	195,000	1,100,000	4	7	2	7
14	2,125	1,240	5,043	12,060	1,450,000	2,130,000	4	8	2	14
15	78	184	63	1,363	540,000	920,000	4	28	2	6
17	4	45	85	460	111,000	35,600	3	17		
18	60	238	155	2,060	62,000	480,000	5	8	0[3]	6
All stations										
	90	330	240	1,670	257,000	723,000	4	18	2	7

1 only those stations with observable flows were sampled
2 Dry : stream sampled following period of no precipitation
Wet : stream sampled immediately following or during precipitation events
3 only one sample

Note: all values expressed as geometric means of samples

Occurance of Pseudomonas aeruginosa in Lake Ontario Nearshore Waters at Confederation Park

Population Density per 100 ml	No. of Samples having these densities	
	Wet	Dry
0 - 1	39	29
1 - 2	12	4
2 - 3	3	
3 - 4	6	3
4 - 5		
5 - 6		1
6 - 7		
9		2
10	2	
11		1
14		1
15	1	1
16	1	1
17	1	
19	1	
20	1	
23	1	
37	1	
44	1	
47	1	
48	1	1
71	1	
74	1	

Total Analysis $n_1 = 74$ (Wet) $n_2 = 43$ (Dry)

ration $n_1 : n_2 = 1.72 : 1.0$

Bacterial Population of Lake Ontario Transects
(Geometric mean)

		Distance from Shore in meters					
		1		10		20	
		FC	FS	FC	FS	FC	FS
Dry	Day 1	28	165	23	164	12	80
(July 18-20)	Day 2	8	68	8	22	2	3
	Day 3	14	102	2	8	2	4
Wet	Day 1	36	70	13	40	22	43
(all samples)	Day 2	10	27	13	23	12	26
	Day 3	20	61	2	4	1	4
Wet	Day 1	57	72	25	54	28	55
(Aug. 23 event	Day 2	5	8	5	9	4	12
only)	Day 3	2	8	2	4	1	4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